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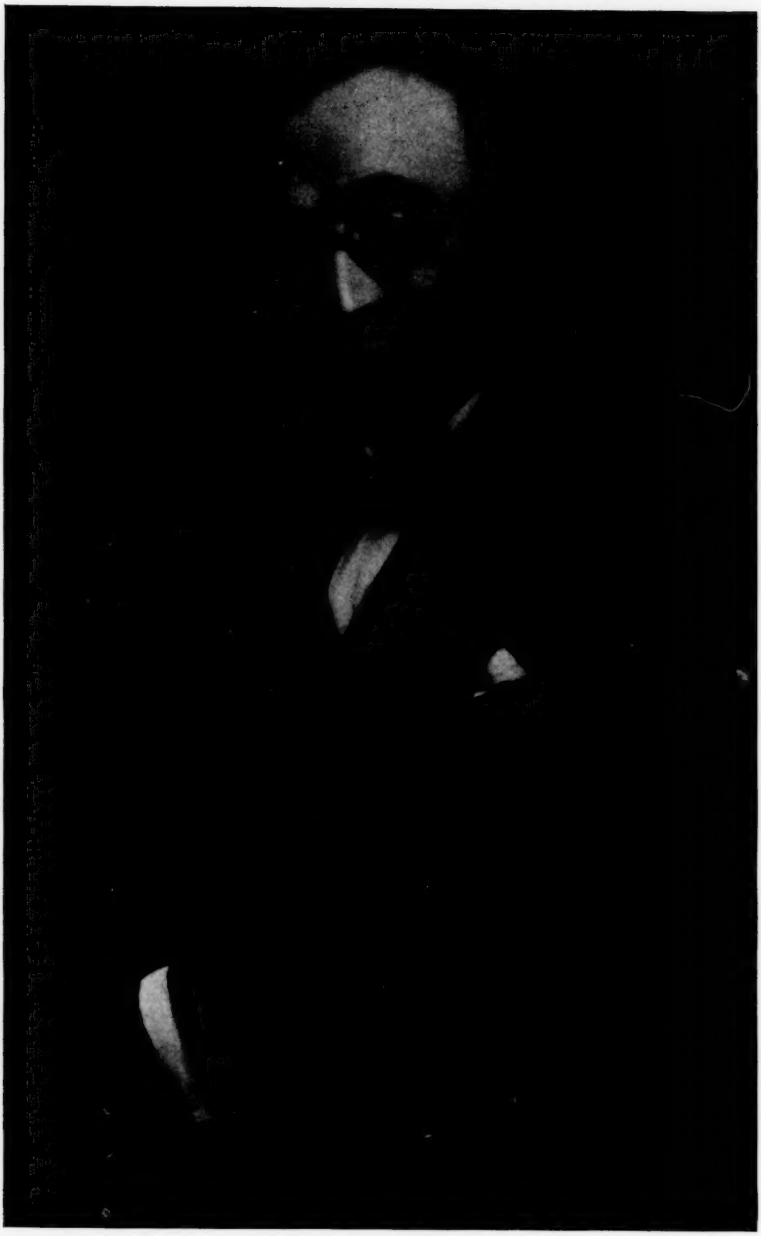

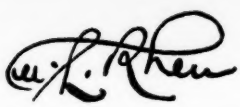

M. L. RHEIN, M.D., D.D.S.[1]

CHARLES F. ASH, D.D.S., F.A.C.D.
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I am grateful for this opportunity to offer a short eulogy in memory of our late friend and co-worker Meyer L. Rhein. Dr. Rhein received the M.D. degree from the Albany Medical College in 1880, and the D.D.S. degree from the University of Pennsylvania in 1881. He read his first paper, entitled, "Dental education," before the National Dental Association in 1881. His life should be an example to younger men in that his success was not bestowed upon him, but was won by hard work, and by untiring devotion and study for the betterment of mankind. He wrote fifty original papers, thirteen of which were read before medical societies; many others were published in medical journals. I shall not enumerate them all; a few will serve to demonstrate some of the problems on which he worked:

Dental education (1881). Studies of pyorrhea alveolaris (1888). An etiological classification of pyorrhea alveolaris (1894). Alveolar abscess: preventive and curative treatment (1896). Cure of acute and chronic alveolar abscess (1897). Should the medical undergraduate be instructed in the principles of dentistry? (1900; first paper read before a medical society). The bearing of oral pathology on general medicine (1902). The trained dental nurse (1903). Oral infection and sterilization (1904). Pathologic lesions of the living pulp (1908). Root radiography (1908). Scientific treatment of root canals (1900). Mouth infections: their etiology and a consideration of what effect they may have on the vital organs and other tissues (1912). Interrelationship of physician and dentist (1925). The diagnosis of incipient metastasis and different phases of malnutrition by means of variation and appearance of the dental tissues; read before the

[1] Eulogy delivered in inaugurating the M. L. Rhein Memorial Lectures, Section on Pathodontia, First District Dental Society of the State of New York, at the New York Academy of Medicine, January 16, 1933. [The first memorial lecture was given by Dr. L. F. Barker (*Journal of Dental Research*, 1933, xiii, p. 105; April). Dr. Rhein was one of the founders of the International Association for Dental Research, and a member of the board of editors of the *Journal of Dental Research*.—*Ed.*]

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Pathodontia Section of the First District Dental Society of the State of New York (March 16, 1925; his last paper).

This brief summary will show why this meeting is a characteristic outcome of the efforts of Dr. Rhein to bring about coöperation and good understanding between the medical and dental professions. He introduced in this country the sodium-potassium treatment for cleansing root canals, advocated by Dr. Schrier of Vienna. He was conspicuous in raising money to help destitute European dentists during and after the war. I have asked some of his friends to comment on Dr. Rhein's principal achievements. One wrote as follows:

"While Dr. Rhein made many contributions to dental service, the most outstanding, as I remember, was calling attention to the relationship between oral pathology and systemic disease. While Hunter is given credit for first calling attention to this condition, it is a matter of record that Rhein antedated Hunter by twenty years or more. Only within the past two weeks one of Rhein's former patients told me that as far back as the late eighties Rhein advised one of his friends to look to certain of his teeth because of the infection in and about those teeth, which, if not then impairing his general health, would be likely to if the infection were not removed. I believe that Hunter made his pronouncement in 1910.

"Another outstanding contribution of Rhein's—one not yet accepted in a general way by the medical profession—is his repeatedly stated opinion, backed by clinical records, that early systemic disease frequently manifests itself in and about the teeth. He has frequently made the statement that certain disturbances could, in their incipiency, be readily diagnosed by morphology in and about the teeth"

Another adds:

"His constant insistence on the highest standards in all dental service.

"His constant readiness to fight for a principle he deemed right, or an opinion he thought correct and just, regardless of the odds against him and of the criticism he might incur.

"His constant display of interest in helping the development of sound standards in ethics and in practice, for students and young practitioners."

In addition to these, Dr. Henry W. Gillett wrote:

"His constant habit of investigating new suggestions having to do with the progress of dentistry at first hand—journeying long distances to inter-

view the advocates and discoverers of new processes. A minor example of this occurred at the time I was advocating cataphoresis. After my first papers, Rhein promptly came to Newport by appointment to see a practical case of its use.

"His constant interest and desire to serve his fellow practitioners by spreading information of new methods, new principles, interpretation of recognized principles, and his readiness to serve as clinician or essayist in demonstrating or advocating his views. In this he and Ottolengui constantly gave credit to the late William H. Atkinson, and considered themselves as Atkinson's disciples in this field."

The one conspicuous comment by all his friends was that of Dr. Rhein's readiness to help and encourage the younger men of the profession. My close friendship with Dr. Rhein since 1894 gave me ample opportunity to observe how generously he gave of his time and his talents to the young practitioner. For several years, while I was Supervisor of post-graduate sections of the First District Dental Society Dr. Rhein conducted classes in the treatment and filling of root canals. I attended nearly every session of every section during that time. I remember dropping in at Dr. Rhein's office late in the evening, on three occasions, and found him working with a student over a patient, Dr. Rhein doing a part and the student doing a part of the work. He explained to me afterward that this young practitioner had shown a very keen interest in and aptitude for that particular field, and he was giving him a little extra help—and all this was without pay. I could cite many other instances of Dr. Rhein's generous help to young men, but time will not permit.

Dr. Rhein's principal pastimes were work and more work, with very little time for leisure as most men know it, although he occasionally enjoyed a game of golf, bridge, or chess. With all his activities he was a devoted father, and a loyal and devoted husband. He was fortunate in having Mrs. Rhein's keen and intelligent interest in all his dental activities. Mrs. Rhein accompanied her husband to all the dental conventions, and we all learned to know and love her; and to know, too, that in a large measure Dr. Rhein's good work was due to the helpful companionship of his devoted wife.

I should like to close this eulogy with the following lines from John Sullivan Dwight's "Sweet is the Pleasure:"

Sweet is the pleasure
  Itself cannot spoil!
Is not true leisure
  One with true toil?

Thou that wouldst taste it,
  Still do thy best;
Use it, not waste it—
  Else 'tis no rest.

Wouldst behold beauty
  Near thee? all round?
Only hath duty
  Such a sight found.

Rest is not quitting
  The busy career;
Rest is the fitting
  Of self to its sphere.

'Tis the brook's motion,
  Clear without strife,
Fleeing to ocean
  After its life.

Deeper devotion
  Nowhere hath knelt;
Fuller emotion
  Heart never felt.

'Tis loving and serving
  The highest and best;
'Tis onwards! unswerving—
  And that is true rest.

ON THE INTERESTS THAT PHYSICIANS AND DENTISTS HAVE IN COMMON[1]

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I. INTRODUCTION

An invitation to deliver the M. L. Rhein Memorial Lecture must be considered by the recipient, whether he be a physician or a dentist, as a very high honor. As the physician selected to make the first address, I desire to thank you for the distinction you have conferred upon me, and for the opportunity to discuss a topic to which for more than twenty years I have given much attention; namely to the interests that physicians and dentists have in common.

The ideal of the physician is to promote in every way possible the incidence of healthy bodies and sound minds among the people he serves. The ideal of the dentist is to make every contribution within his powers to the establishment and maintenance of healthy mouths in healthy human bodies. Dentistry and medicine are, therefore, sister professions whose members are at work in the broad field of health services; both professions are being ever more thoroughly educated and technically trained to apply existing knowledge to prevention and cure; and both professions are always earnestly endeavoring to augment funds and competent personnel for the conduct of original re-

[1] The first M. L. Rhein Memorial Lecture. Delivered at a meeting of the Section on Pathodontia, First District Dental Society of the State of New York, at the New York Academy of Medicine, January 16, 1933. An introductory eulogy was delivered by Dr. C. F. Ash (*Journal of Dental Research*, 1933, xiii, p. 101; April.)

search that will still further extend knowledge and improve technique in their respective domains.

During the past few decades our knowledge of the reciprocal relationships between disease within the mouth and conditions elsewhere in the human body has been enormously increased. We have been made familiar with the many ways in which intra-oral disease may affect deleteriously other parts of the body and the human organism as a whole; and we have also been learning gradually the significance of the functions of the other parts of the body for the welfare of the teeth and gums, on the one hand, and for the pathological changes to which they may be subject, on the other.

Not only those who knew the late Dr. M. L. Rhein personally, but also those who have followed medical and dental literature, must have been impressed with the deep and sincere interest shown by him in the interrelationship of dental and general medical problems. He urged upon physicians and dentists the importance of acquaintance with the physical condition of the mouth in all circumstances, and emphasized the frequency with which variations in color, consistency, shape and character of the gums, pericementum, and the mucous glands, are observable in association with different diseases that attack the body. He believed that each disease has its own mouth indicator that can be read by the discriminating observer; in other words, that inspection of the mouth will frequently reveal pathognomonic evidence of special systemic diseases. His profound conviction and his eager discussions of the subjects mentioned undoubtedly stimulated interest among his dental colleagues and among medical practitioners—interest that led to honest constructive criticism and to further fruitful research. And it is precisely because of the desire that was evinced by Dr. Rhein for the promotion of the interest common to dentists and physicians that I have chosen that topic for consideration in this Memorial Lecture.

Among the problems of common interest to which I should like to direct your especial attention I may mention (II) the recognition of abnormalities of the teeth and gums and the determination of in-how-far they are a menace to the rest of the body and in-how-far they are the results of abnormalities in other parts of the body; (III) the etiology of these abnormalities; (IV) the curative and the preventive measures

available in the existing state of knowledge; and (v) the social and economic conditions by which our two professions are faced.

II. RECOGNITION OF ABNORMALITIES OF TEETH AND GUMS

Of the problems common to our two professions undoubtedly one of the most important for the general welfare of the people is the timely recognition of pathological conditions. Though every member of the population should see a physician and also a dentist, at regular intervals, this hygienic rule is rarely adhered to. After one or another abnormality has appeared in the mouth, the opportunity for recognizing its presence may come first either to the physician or to the dentist. The competent dentist, with his thorough training in all methods of oral examination by means of modern dental technique, ought not to overlook anything of importance. The practising physician, however, even the recent graduate of the best medical school, will but rarely have had opportunity for training in all the technical methods of dental diagnostic study. But physicians, in making routine examinations of patients, should always examine the mouth carefully; and particularly, when the history given by the patient is at all suggestive of the existence of conditions known to stand sometimes in relationship to pathological conditions of the mouth, should be especially on the alert for the discovery of anything suggestive of abnormalities of the teeth, gums, or other mouth structures. Certainly the "family doctor" should have no difficulty in recognizing immediately the evidences of missing teeth, loosened teeth, dead teeth, extensively carious teeth, gum boils, out-spoken suppurative pyorrhoea, fistulae, spongy or bleeding gums, or marked malocclusion and dento-facial deformities. Nor should he overlook a supernumerary tooth or a lead line upon the gums. If he has been trained in endocrinology, his attention will probably be attracted by the horizontal lines of enamel defect seen in chronic tetany (due to chronic hypoparathyroidism), by forms of abnormal dentition often seen in hypothyroidism, by the peculiar spacing of the incisors in some cases of hyperpituitarism, or by the peculiarities of the incisor teeth in status thymicolymphaticus. He will remember that every "dead" tooth should be x-rayed at least every six months to rule out the development of periapical infection. But many minor abnormalities of the teeth and gums may easily escape

the average medical practitioner's attention. Slight hypoplastic conditions, less marked malocclusion, minute cavities due to incipient caries, and, above all, certain forms of paradentosis, are very likely to be overlooked. It will be noted that, among these conditions that often escape attention by the physician, there are several for which it is exceedingly important that dental treatment be instituted promptly to prevent the development of more serious conditions.

From what I have said the necessity of the closest coöperation of dentists and physicians for the early recognition of abnormal states within the mouth must be obvious. A physician cannot do better than to urge his patients to visit their dentists regularly, and dentists will do well to urge their patients to have periodic health examinations by their physicians even when they feel well.

For many years, now, I have been making general diagnostic surveys by the method of group practice. The patients who come are usually referred by other physicians because of some obscurity of diagnosis, or because of unsatisfactory progress towards recovery, or for some other special reason. These patients are under observation for from two to five days, during which complete examinations are made, including a full anamnestic record; general physical examination; routine laboratory examinations of blood, urine, stomach juice and feces; sometimes special laboratory tests (like basal metabolism, cerebrospinal fluid, blood chemistry, glucose tolerance); x-ray examinations, when indicated; and examinations by specialists in particular domains when the history, or the physical examination, suggests the need of them. In the making of such general diagnostic surveys I have been greatly helped by reports from skillful dentists whose technique of examination I knew to be adequate; in many cases these dental reports have yielded the clues to mysteries previously unsolved. I desire here publicly to thank the dental profession for the very great help they have been to me personally in the diagnosis and treatment of many difficult cases.

Even in cases in which dental disease is a very important factor, the general diagnostic survey often reveals a number of other concomitant pathological conditions the recognition of which is important for the patient's welfare. A general diagnostic survey adequately made usually results in a multidimensional diagnosis, which affords

indications for treatment in more than one domain. A ready explanation of many of the failures in ordinary medical practice is to be found in the fact that the practitioner has been satisfied with a unidimensional diagnosis when he should have pushed his inquiries far enough to discover the multidimensional disturbances concerned; and no small part of this failure in practice has depended upon the tendency of patients to go directly to specialists, who practise in single domains, rather than to make application for study to general practitioners or to all-around internists, and to allow them to decide which, if any, specialists should be consulted as a part of a general diagnostic study.

III. ETIOLOGY OF ABNORMALITIES OF TEETH AND GUMS

In the emphasis that I have laid upon studies of the mouth as a part of any general diagnostic study of a patient, you will, I feel sure, concur. But we should never be satisfied with the mere recognition of abnormalities of the teeth and gums any more than with the mere recognition of abnormalities elsewhere in the body. In every diagnostic study we should, I think, consider in addition to the pathological anatomical changes in structure (*pathological anatomical diagnosis*) at least two other matters, namely, the disturbances of function involved (*pathological physiological diagnosis*) and the causes (single or multiple) of the abnormalities (*etiological diagnosis*). It would take too long to discuss in detail these three sub-divisions of diagnosis; but because of the contemporary interest in the origin of dental caries, of paradentosis, and of malocclusions, I should like to say something more about the etiological factors concerned.

Considerations of etiology, though most important, are among the most difficult of our medical and dental tasks. Still, by attacking etiological problems systematically, by making careful analyses of possible constitutional factors on the one hand and of possible environmental factors on the other, studies of causation have in recent years been greatly promoted. If we make use of the terms of the geneticist, each patient who comes to us for study is to be regarded as a *phenotype*, that is to say, as the resultant of the interaction of factors of heredity (or *genotype*) derived from the two parents with factors from the surroundings from the moment of fertilization to the moment of examination (*paratype*). This phenotype (or compound of genotype

and paratype) contains all the constitutional factors concerned in etiology; any other etiological factors concerned must be environmental. It has been found that phenotypic or constitutional etiologic factors usually fall within the class of *predisposing factors* of disease or abnormality, whereas the environmental or conditional etiological factors fall within the group of so-called *precipitating* or *realizing* factors of disease or abnormality.

This separation of predisposing factors from realization factors is often very helpful in the explanation of causation that might otherwise be obscure. Take a single example, namely, dental caries. Acid fermentation in mouths imperfectly cared for has long been held responsible for dental caries; but physicians and dentists have had to recognize that caries frequently occurs in relatively clean mouths, and that in many notoriously ill-kept mouths dental caries may be relatively slight, or even absent. The necessity, therefore, of studying predisposing causes of caries within the phenotype, in addition to the precipitating causes of caries from the immediate environment of the teeth, becomes obvious. Again, on further analysis of the constitutional predisposing factors concerned, we often find that they have had their origin in baneful environmental influences that acted earlier in the life of the organism, that is to say, were of paratypic rather than genotypic origin in the constitution. As an example of this I need only remind you of the views at present held by some with regard to the constitutional susceptibility of the deciduous teeth of an infant due to abnormalities of the blood reaching the foetus from the mother who during pregnancy has been ill, or who has failed to receive an adequate diet. Or to take another example, a child with typical Hutchinsonian teeth suffers from congenital syphilis. This dental malady, though of constitutional origin, is not of genotypic origin necessarily, for the etiological agent, the *Treponema pallidum*, entered the child's organism as an environmental factor during intrauterine life. On the other hand, the facial and palatal conformation of persons of apoplectic habitus and of those of so-called asthenic habitus, with their corresponding dental features, are believed to be due to genotypic factors in the constitution rather than to paratypic components, as are the tendency to obesity, in the one case, and the tendency to undernutrition, in the other.

The fact that dental caries is encountered in 90 percent of children, though long known or suspected by dentists, has been corroborated by studies of public health officials of over 12,000 white school children between the ages of 5 and 19, examined in the year 1931. The highest percentage of carious temporary teeth was in the 7-and-8-year group; whereas the percentages in decay of the permanent teeth increased rapidly up to the age of 8 and more slowly later. These findings in America are most interesting in comparison with those made in various groups of children in certain foreign countries where sometimes as many as 82 percent are free from dental caries.

You are all aware of the many studies that have been made of the diets of children and of experimental animals in relation to the origin of caries; you know also the belief of some that there is lack of resistance of the teeth of the new-born to caries when the mothers have been improperly fed. You are familiar with the recent work that has been done upon the vitamin content of foods in relation to caries and the importance attributed to vitamins A, C and D; and, more recently, you have followed the discussions of the significance of calcium and phosphorus supply to the organism, and its relations to vitamin D on the one hand and to parathyroid function on the other.

Since there are no less than 35 different factors essential to an adequate diet, great caution must be observed in drawing final conclusions with regard to the influence of any single factor of diet. In the presence of so many variables, the resort to animal experiment in attempts to solve the problems of dietetic relations to dental caries is praiseworthy because of the greater possibilities of rigid control under experimental conditions.

Dental caries, oral sepsis, and malocclusion are so important for single persons, and for society as a whole, as to merit continued research into their causes and their effects; such original inquiries are justifiable at public expense if funds from private foundations should not be sufficient to maintain them. Despite the great increase of dental care in recent years there is still an enormous amount of neglect of abnormal oral conditions, with detrimental effect upon digestion and nutrition, and large incidence of disease and death due to infections and intoxications originating in the mouth.

IV. CURATIVE AND PREVENTIVE MEASURES AND AGENCIES

In the history of medicine, studies of methods of cure of maladies have always long preceded studies of prevention of the same maladies. This fact is just as true of disease and abnormality within the mouth as in other parts of the body. Our dentists have developed a truly marvelous technique for repairing the damages due to dental caries, for the eradication of foci of infection in the mouth (gingival and periapical), for safe and painless extraction, for the efficient and artistic replacement of teeth that have been lost, for the overcoming of many forms of malocclusion, and for the maintenance of the normal functions of the teeth. Important as these achievements of dentistry have been, the prevention of the disorders mentioned is a far more important task. If the knowledge already possessed could be generally applied, dental caries, paradentosis, and malocclusion, together with their sequels, could be largely prevented. When I think, too, of the amount of arthritis, neuritis, nephritis, pyelitis, endocarditis, anaemia, and undernutrition that I have seen during my life-time directly referable to diseases of the teeth and gums, I am not only ready but eager to join the ranks of those who are energetically endeavoring further to educate our two professions and the public generally as to the importance and possibilities of measures for the prevention of oral sepsis.

Preventive measures in dentistry began with education as to the desirability of cleanliness in the mouth. Children and adults were taught how and when to use the tooth brush, and later were instructed in the importance of the use of foods that cleanse the teeth, foods of fibrous character and of high calcium content, including fresh fruits (like apples), whole-wheat or bran bread, vegetables like celery, radishes, cabbage, cauliflower and carrots—in other words, food stuffs that demand vigorous mastication, since chewing stimulates the flow of saliva and increases the blood supply to the jaws and the pulps of the teeth, and the friction of the food scours and polishes the teeth. The excessive use of sweets and starches and of candies and chocolates was discouraged and, more recently, the importance of an abundant supply of vitamins and of mineral salts in the diet, as well as of proteins containing all the amino acids, became recognized.

For a long time, only the permanent teeth were thought to be very important but, later on, as knowledge grew, dentists and physicians

instructed families in the importance of care of and attention to the deciduous teeth. It was soon learned, too, that breast feeding is better for the infant's teeth than are prepared infant foods, especially if the mothers' diet be adequate. And, still later, it was surmised that the diet of the expectant mother is important for the growth of the foetal jaws, and for the developing deciduous and permanent teeth in those jaws before birth. Today, the expectant mother is advised to have sufficient milk, green vegetables, fruits, whole-wheat bread and cereals, and enough calcium and phosphorus in the diet to promote the bone and tooth formation of the foetus within her womb.

A whole series of agencies must be utilized to bring these methods of prevention forcibly home to the public. Every practising physician and every practising dentist should participate in this campaign of popular education in preventive measures. "Family doctors" and obstetricians should advise expectant mothers about diet and general hygiene and, if new-born infants can not be breast fed, they should see to it that the infantile diet is adequate. Pediatricians should coöperate with family physicians during the pre-school periods; and, after entrance to school, regular mouth examinations should be made by school physicians and regular inquiries should be made regarding diet. After school and college life are over the practice of periodic health examinations by the family physician and by the family dentist should be encouraged. Medical and dental societies should provide for occasional public lectures upon the prevention of oral disease, and the movies and the radio may also be utilized in this preventive campaign. The method of demonstration work in schools for children under twelve, introduced by public health officials in San Joaquin, California, would seem to be worthy of consideration elsewhere, since the prevention of dental decay, of oral sepsis, and of neglected malocclusion is one of the most important problems of public health today.

V. CHANGING SOCIAL AND ECONOMIC CONDITIONS

Failure to apply the curative and the preventive methods known to physicians and dentists, though largely due to ignorance, is partly due to social and economic conditions. The well-to-do and the very poor are perhaps, on the whole, better cared for than those of intermediate status, since people of means can command the best medical and den-

tal services, and are likely to be better informed with regard to the importance of such services, and the very poor can receive good attention and proper advice in public clinics free of charge. In a survey, recently made for the American Child Health Association, of the dental care given to children between the ages of three and five years it was found that there are great differences in different parts of the country, the best care being four or five times higher than the average care in certain places, and only one-tenth of the average in certain other places. It was found that about ten times as many children apply to physicians for health advice as to dentists. Even among the well-to-do only about one child in five made application, whereas in the poorer classes only one child in twenty-five so applied. Either the parents of these children were not alive to the needs, or there must have been lack of facilities to meet the needs. How can this lack of provision of adequate medical and dental care, especially preventive care, be overcome? There are strong differences of opinion as to the more desirable ways and means.

The Committee on the Costs of Medical Care, after a five-year study of conditions in the United States, has recently published a report in which a majority of the Committee recommends making a trial, in certain communities, of group services providing all needed medical and dental care, to be paid for by a group method of purchase through which each member of the group pays a stipulated but reasonable amount each year. The members of the Committee favoring such attempts at group practice and group purchase believe that adequate facilities can be efficiently organized to achieve economies in giving medical care without sacrifice of the quality of the services; that the returns to physicians and dentists could be increased or stabilized above the level of the average net income of private workers; that the burden of the costs of illness could thus be distributed over a large number of people; and that, by the system of small periodic payments by each participant in a group, the total sum of money made available for the care and prevention of illness would be larger than that supplied at present under the method of private practice by single individuals. On the other hand, a minority group of the same Committee held views that are in strong opposition to the views of the majority, since they feared that adoption of these recommendations might destroy

the personal relationships between patient and practitioner; might lead to the lay control of professional work; and might degrade and demoralize the medical, dental, and nursing professions. Many physicians and dentists in private practice also fear anything like panel dentistry or panel medicine, state medicine or state dentistry, and will do everything possible to prevent their adoption. It seems certain that there will be active discussion of these and allied topics in the immediate future. It is of course desirable that the people shall be given adequate medical, dental, and nursing care. It is also desirable that those who give the care shall be adequately remunerated, and that those who receive the care shall be able to secure it without actual financial hardship. It is also very important that the personal relationship of practitioners and patients shall be preserved; that strictly professional services shall be kept under strict professional rather than under lay control; and that the financial as well as the other varieties of reward of the professional personnel shall be sufficient to attract enough persons of character and ability into their ranks. Social and economic conditions are always changing. Medicine, dentistry, and nursing, must discover the proper forms of adaptation to these changes. Whatever is best for the public is likely, in the long run, to be best also for those that serve the public. With good will on the part of all concerned, we can feel sure, I think, that, in time and after full discussion and experiment, satisfactory forms of adjustment will become evident.

DIAGNOSTIC FACTORS IN PARTIAL-DENTURE PROSTHESIS[1]

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When the subject of partial dentures is mentioned one is reminded of Mark Twain's comment on the weather: "Everybody talks about it, but nobody ever does anything about it." Any moot subject is always indicative of a particular unrest, so that it seems reasonable to suppose that partial dentures have not been an unqualified success. For every paper that has been written on diagnosis for partials, a hundred have been written on the mechanics of construction. Such a situation, in view of the repeated failures experienced, leads one to think that perhaps a large amount of effort has been expended in the wrong direction.

The requisite for any restoration in the mouth is that physiologic function be restored and maintained. There are types of cases where such a result is possible of attainment with partial dentures. Unfortunately, in the majority of cases a partial is selected as the method of treatment because the operator can think of no other way of making the restoration than by resorting to full dentures, and the patient objects to the full denture. On such a basis of selection the large percentage of failures should not excite wonder. The efficiency of an appliance is dependent upon the intelligence of its application, and mechanics will not offset the violation of biologic laws. A set of casts sent to the commercial laboratory with instructions to supply the missing teeth will give a successful result only as often as the laws of accident will permit. The several biologic factors must be considered and evaluated, and a foundation prepared that will make it possible to construct a prosthetic piece that embodies in the simplest form the

[1] Read at a meeting of the Rhode Island State Dental Society, Providence, R. I., January 26, 1933.

few mechanical principles necessary for its retention and function as a part of a harmonious whole.

When we speak of the mechanics of construction we mean the assembling of the several parts of the appliance. Overemphasis on types of clasp, stress breakers, freak skeleton design, etc., has confused the issue. This is but a natural result of an effort to correct deficiencies without sober reflection and analysis of such common difficulties as occlusal disharmony, loosened abutment teeth, lack of stability under stress and in repose, and the various degenerative changes that militate against the permanency of a partial-denture restoration. The mechanical factors are some form of tissue-contact saddle that will carry and support the supplied teeth; some form of clasp or modified clasp that will act as a direct retainer, and also allow the saddle to move with the movable soft tissue and tooth support as the support moves in function; some form of indirect retainer either as extensions, or opposing saddles, and adhesion. Balanced occlusion is a factor, in so far as it causes the directional stress in function to be so applied as to become an active adjunct to retention, by causing the finish of the biting excursion from point of cusp to centric occlusion to reseat the saddles, and to return them to close contact with the soft tissues and thereby reëstablish adhesion at the close of each excursion. When a bolus of food is placed between the teeth, the teeth themselves are out of contact. The act of passing the teeth through the food naturally tends to unseat the denture. As the teeth pass through the bolus and come into contact themselves on the functioning side, this tooth contact will continue to dislodge the denture unless at the time of contact there is a balancing contact on the opposite side. With such contact on both sides it will be readily seen that, in the finish of the biting excursion, an equal force will be applied to both sides of the denture simultaneously, and this equally distributed force must of necessity press the saddles into close contact with the supporting mucosa.

Muscle balance is essential for much the same reason. The temporomandibular articulation is capable of an infinite number of movements, all of which are caused by the muscles of mastication acting severally or in concert; but when full closure is reached, the concerted action of the muscles of flexion participating in this movement, even though the individual muscles are apparently pulling in different directions,

produces a composite resultant that is directed to a common center. When the arrangement of the teeth is such that this force is equally distributed to the saddles, through the long axis of the teeth and the ridges, toward this common center, we say the case is in muscle balance. When this force is not so distributed, it becomes torsional. This is best illustrated in the following way. If a number of threads are attached around the edge of a square of pasteboard, and equal forces are applied to all the threads simultaneously in a direction away from the cardboard, the square will remain stationary. If an unequal force is applied, the card will move toward the direction of the heavier pull either laterally or in rotation. In like manner, unequal muscular tension causes a denture to slide or rotate on the soft-tissue base. This twisting is transmitted to the abutments by the direct retainers, and they in turn are subjected to a torsional stress. Even though the torsion may not be sufficient to cause the abutment teeth to loosen, the retention is impaired because two masses with an intervening liquid lose adhesion under torsion. Every one is familiar with the phenomenon of two glass slabs pressed together with water between. They adhere so closely that it is necessary to apply great force to pull them apart if a direct separation is attempted. If, however, a force is applied that rotates them on each other or slides them sideways, they are readily separated. It is this sliding or twisting movement that we have in mind when we refer to torsion of teeth or saddles.

The biologic factors are not easy to epitomize. We shall attempt to rationalize several deductions from clinical experience with anatomical and physiologic fact, so that definite premises on which to base procedure may be established. The supporting base for a partial denture is bone, soft tissue, and teeth, of which bone is the most fluid. Fractured bones unite very rapidly in comparison to repairs of other tissues in the body. Pressure from an aneurism of the aorta causes resorption of the adjacent vertebrae. You are all familiar with resorption of bone in the jaw from the pressure of cysts. The practice of orthodontia is dependent upon this characteristic of bone, as it is resorbed in the direction of the applied force in tooth movement and laid down again to support the tooth in its new position. It must, however, be remembered that such modification occurs more readily when the applied force is in a direction different from that of normal func-

tion, as for instance, the intrusion of a tooth, a very difficult procedure as compared to lateral movement. This ready susceptibility of bone to modification is largely responsible for the changes that take place in the position of teeth and in changes in directional muscle pull.

Bone is constantly subjected to tension and pressure stresses. The reaction to these stresses caused Wolff to formulate the "*Law of the Transformation of Bones*," in the following terms: "Wheresoever stresses of pressure and tension are caused in a bone, be it by pressing forces or by pulling forces, formation of bone takes place." While this "law" is not now wholly tenable, in that tension stresses do not have the power to govern the mathematical form of bones, functional pressure is indeed an important factor in the size of bones, the form being given. Functional pressure is applied to the bones of the face and jaws through the action of the muscles of mastication operating with the teeth as fulcrumage points; that is to say, the jaw is the lever, the muscles are the power, the food is the load, and the point of contact where the leverage is applied, which is the teeth, is the fulcrum. The head of the condyle is never normally a fulcrumage point in centric occlusion. In intrauterine life the ridges are in contact and carry the load of spasmodic muscle-pull, as is evidenced by the hyalin cartilage of the meniscus, which develops as a disk instead of a ring, as does that of the knee joint. The erupting teeth carry the load as they come into occlusion. Not until teeth have been lost, and the posterior support removed, is a heavy load transmitted to the meniscus in centric occlusion. It is true that when an incising bite takes place, or where a bolus of food is between the teeth, some pressure is applied by the condyle head to the meniscus; but at such time of application, the head of the condyle is forward as is the meniscus, and any excess of pressure will be accommodated by the meniscus gliding backward in the fossa. For our *first premise* we may say that a restoration to be physiologic must provide for a centric-occlusion relationship that will place the fulcrumage in full closure on the bicuspids and molars.

Whenever teeth become worn and abraded to the point of interlocking cusps, lateral movement then tends to put a twisting or torsional stress on the teeth so affected. The supporting buttress-structure of bone is destroyed, pockets and infection follow, and the teeth loosen to the point of uselessness. This condition is also seen in mouths having a

full complement of teeth with deep cusps and bell-shaped crowns that, at about the adult period, begin to show evidence of gingival infection, subsequently followed by extensive periodontal disease. The torsional factor has undoubtedly been introduced in such cases by a slight flattening of the cusp-contact surfaces from wear, so that frictional resistance to functional lateral movement has been greatly increased. At the same time the pterygoid muscles, which do not reach their full development until adult life, are capable of applying a force sufficient, in lateral movement, to apply a rotation stress to the long axis of the teeth. For our *second premise* we can say that all torsional stress should be avoided.

The investing mucous membrane has a protective keratinized layer that is in effect a specialized tissue. When slight irritation is continually applied to the gums this layer, which is composed of flat, non-nucleated platelets, thickens in much the same way that the hand or foot will become calloused. When a fixed bridge is inserted in the mouth, and the gingival edge of a facing is placed in close contact with the mucous membrane so that just a slight blanching takes place, the soft tissue accommodates itself to the pressure. If, however, the pressure is in excess of the amount that the soft tissue can bear, an inflammatory process ensues. Nature protects herself in the only way possible, which is by the absorption of some of the underlying bone. Where saddles are constructed with a tissue-bearing area that is only slightly larger than the occlusal surface supported, the same condition is produced and extensive absorption takes place. Hence for our *third premise* we are justified in assuming that saddle areas should be proportionately as large as possible.

When the posterior teeth of the natural dentition have been lost on one side only, the patient very often develops a unilateral, traumatic, condylar arthritis. The fulcrumage of the affected side has become changed so that the anterior teeth and the head of the condyle carry the load of muscle-pull which is exerted between these two fulcrumage points. This pull throws a heavy load on the articular membranes and the meniscus, and an inflammatory process is the result. The affected joint is always on the non-functioning side. With this condition also we usually find that the resultant loss of facial dimension on the non-functioning side has produced a change in the plane of occlusion, so that

the teeth are functioning against an inclined plane and the mandible tends to slide laterally, producing a lateral-thrust bite that is often in excess of the ability of the supporting bone to accommodate. This lateral thrust is not in the direction of normal function and for that reason causes bone destruction. Beginning bone-loss is always evidenced about the necks of the teeth subjected to this abnormal stress by a break in the even curve of the free gingival gum margin. This break occurs as a V-shaped notch and is always situated directly opposite the point of abnormal contact. Since the natural teeth will support a heavier load than will saddles, the advisability of having the amount of closure governed by natural teeth is evident. It is also apparent that a strong support on one side of the jaw without a corresponding support on the other side will result in destructive changes. It will thus be seen that for our *fourth premise* we can say: Use natural-tooth stops, wherever possible, if equally distributed on both sides. Our *fifth premise* is a corollary of the third and fourth in that it is arrived at through a combination of the two: Alternating supplies and natural teeth, with the natural teeth in opposing jaws contacting with artificial teeth of the supplies, should be avoided.

It is a well-established fact that the contractile power of a muscle is greatly increased under load. The muscles of expression are loosely attached to the under surface of the skin. They draw the skin into lines and wrinkles as they act over the supporting buttress-structure of bone. If lost alveolar tissue is not restored, support is lacking and these muscles lose tone. When full facial-dimension is not restored, the levator muscles do not fully function, and the depressors that oppose them suffer a corresponding loss of function with partial atrophy, resulting in an appearance of senility in the tissues of the face and neck. The act of swallowing requires the placing of the teeth in contact. When dimension has been lost and the bite closed, this action becomes a decided effort and the number of deglutitions is greatly reduced. As a result, saliva lies on the floor of the mouth for prolonged periods, and the tendency to salivary deposits is increased. The negative pressure produced by the tongue in contact with the palate while swallowing assists in the drainage of the sinuses. Decreased drainage causes congestion of the mucous membranes, sometimes spreading to the Eustachian tubes by way of the throat, resulting in catarrhal deaf-

ness. This probably explains the fact that some patients have had their hearing greatly improved by restorations that supplied lost intramaxillary space. It is well to remember that this is only one of several types of deafness, and any sweeping declaration as to the efficacy of such treatment in all cases is absurd. For our *final premise* we say that normal facial dimension should be restored.

Let us sum up briefly and see what may be the application of the foregoing. If these premises are sound, to construct a partial denture that will at least give promise of a degree of permanency we must have, to start with, a healthy foundation. All teeth that cannot be placed in a state of health should be extracted. Unapposed posterior teeth that cannot be brought into the line of occlusion should be extracted. Natural-tooth stops that are unilateral should be removed. In cases where teeth alternate with spaces, and the teeth are so placed as to make it impossible to obtain sufficient proportional saddle-area, the removal of some teeth is necessary. When the teeth that cannot be integrated to a normally functioning result have been disposed of, the next step is to determine the amount of opening necessary to restoration of dimension. The opposing natural-tooth stops are then built to that level, and the case is ready for procedure on a mechanical basis. In our experience, in this connection, no one system or type of appliance possesses any advantage over another, in any given case, except in so far as combinations of special features may make it possible to satisfy these several biologic premises in the simplest way. Each case presents a different set of factors and must be considered entirely on an individual basis. Simplicity of design and construction are the chief considerations from a purely mechanical standpoint, ever being mindful that the chief requisite is to satisfy the biologic equation.

On such a basis of selection, the number of cases adapted to this type of restoration is greatly reduced; but the ones that are built will at least have some chance of being successful from the standpoint of preventing further untoward sequelae, and of providing the patient with an appliance that is comfortable and functions in harmony with his physiologic mechanism.

THE RELATION BETWEEN THE SHAPE OF THE OCCLUSAL SURFACES OF MOLARS AND THE PREVALENCE OF DECAY[1]

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During the past ten years much interest has been aroused regarding the high frequency of decay in the occlusal surfaces of molars. It has been suggested that the shape of the tooth has something to do with this liability. Pits and fissures may possibly be more closely related to the shape of the tooth than has been suspected. In other words, the occlusal surfaces where decay is more frequently found might have some correlation with the angles of the inclined planes of the cusps. The simplest physical characteristic of the occlusal surface of a tooth that can be connected with the liability for decay is the formation of the enamel at the union of cusps at their base. Does the angle or inclination of the surfaces of the cusps toward each other have any relation to the liability? To answer this question, careful consideration must also be given to the steepness of the walls that form the valley between cusps. To determine the facts, an intensive study of this question was undertaken.

Cases between 7 and 25 years of age (average age, 17.5), where conditions were favorable for accurate measurements, were selected. It was necessary to choose teeth whose cusps were intact and not worn by abrasion—and in which the outer enamel had not been broken down by caries enough to prevent a good impression and subsequent accurate measurements. Because of the uncertainty of correct reproduction of lost tooth-structure, teeth having fillings in the involved area were omitted. *Upper right first permanent molars were selected for study;* only representative ones were included. All measurements were made from stone models with a Stanton Surveyer,

[1] Read at a meeting of the New York Section of the International Association for Dental Research, Guggenheim Dental Clinic, New York City, February 16, 1933.

designed and constructed by Dr. Frederick L. Stanton of the New York University Dental College. This machine operates on the principle of the vernier scale, making all measurements accurate to 0.1 mm. Accurate impressions of the occlusal surfaces were taken with modeling compound, which was found best suited for this work; no separating medium, which might obliterate fine pits, was required as is necessary when plaster is used. Healey's Artificial Stone was pressed into impression, section by section, as one manipulates amalgam in making an amalgam die. The base of the model was squared to fit

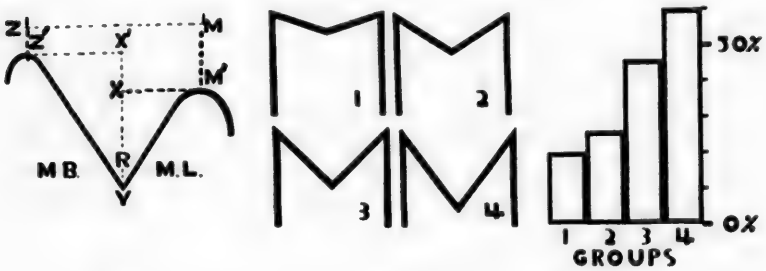

FIG. 1 FIG. 2 FIG. 3

FIG. 1. DIAGRAM SHOWING THE LINES OF MEASUREMENT

FIG. 2. DIAGRAM REPRESENTING *R* IN RELATION TO STEEPNESS OF THE SIDES OF THE VALLEYS

FIG. 3. DIAGRAM SHOWING THE LIASON BETWEEN THE FREQUENCY OF CARIES AND THE INDEX NUMBER (*R*)

Abscissa: groups in fig. 2. *Ordinate:* caries in percent (0–50)

into, and be attached to, the moving platform of the measuring instrument.

No definite point on a cusp can be indicated as its tip. The highest portion, or upper extremity, of the cusp was selected. Measurements of the mesio-lingual cusps were made from the tip of each to the deepest point of its inner outline. Measurements were also made, in each instance, from the tip of the mesio-lingual cusp to the tip of the mesio-buccal cusp. The caries of the area involved—the most susceptible area between the mesio-lingual and the mesio-buccal cusp—namely, caries in the central pit, if any, was noted and recorded. This area, within the scope of our measurements, is the

portion of the tooth surface with which we are directly concerned. *Fig. 1* shows the points of measurement. The distances X, Y and Z, M were measured. Representing the distance X, Y by A, and the distance Z, M by B, and considering R as the index of steepness, or the ratio of depth to breadth of the mesio-occlusal valley, we have $\frac{A}{B} = R$. Substituting for A and B the corresponding measurements, a series of values, each representing R, were obtained. These figures were arranged sequentially, from the lowest (0.17) to the highest (0.74). This ratio, R, has been used as a variable against which the frequency of occurrence of caries has been displayed.

To investigate the relative frequency of caries with respect to the value of R, the observed cases were divided into four groups of twenty-five each, showing the following range of R: *Group 1*, less than 0.30. *Group 2*, less than 0.35, more than 0.30. *Group 3*, less than 0.42, more than 0.35. *Group 4*, more than 0.42. *Fig. 2* illustrates the appearance of R in each of the four groups. The diagrams were made by directly surveying, from a model in each group, the angle of the mesio-occlusal valley, which was determined by surveying the three points, Z', Y, and M', used for the original measurements. The Dental Pantograph, designed and constructed by Dr. Frederick L. Stanton of the New York University Dental College, was used to construct these angles.

Of a total of 100 teeth, the number having caries in the central-pit area was 38—62 were non-carious. For each of the groups, the number in which caries occurred was counted and the frequency computed:

Quartile of R	*Frequency of caries in central pit*	*Non-carious*
Group 1	0.20	0.80
Group 2	0.26	0.74
Group 3	0.46	0.54
Group 4	0.60	0.40

The steeper the sides of the valley, the greater the likelihood of caries in the pit (*fig. 3*). The above statistical data show that the teeth in the lower quartile of those examined (that is, those which had the shallowest valley) suffered caries to the extent of only 20 percent, or an average of one in five; whereas, with increasing steepness of the

sides of the valley, the percentage of caries likewise rose. Thus, in the second quartile, the proportion of caries was 26 percent; in the third, it was 46 percent (nearly 1 in every 2 teeth examined); in the fourth, where the sides were steepest, it was 60 percent. *Fig. 3* delineates the liason between the frequency of caries and the index number. The decided tendency of caries frequency to increase with steepness of the sides of the valley is clearly shown. This research is still in progress.

WHAT IS ORAL SURGERY?[1]

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In one of my papers, entitled "Clinical oral surgery, with special emphasis on its related pathology: Part three," I remarked: "In conclusion, I again wish to emphasize my belief that the establishment of many laboratories for the sole purpose of studying pathological conditions of the mouth, in close coöperation with oral surgeons, would rapidly increase our knowledge very much."[2] This statement was made in the early part of 1930. The present financial situation has not altered the principal thought expressed at that time, but necessitated a change in its execution, which is considered below. However, the pathologist is only one of the many specialists with whom we must coöperate. Is the oral surgeon justified to operate without consulting the family physician in case of heart, lung, kidney, or other disease in the field of internal medicine? I am personally quite aware of, and have been grateful on many occasions for, assistance received from general dental practitioners and dental specialists in dealing with cases requiring root-amputation, alveolotomy, surgical prosthesis, and treatment for fractures. No matter how well educated medically the oral surgeon may be, the pediatrician will always prescribe the formula for the feeding of the infant to be operated upon for harelip and cleft palate. Ophthalmology when dealing with a possible oral focus, rhinology when in doubt about the etiology of a sinus affection, and otology, where there are referred pains, are branches of medicine that assist us in the proper care of our patients. Today the oral surgeon also acts as a diagnostician, and therefore certain soft-tissue lesions of the mouth necessitate an examination of the skin and

[1] Read at a meeting of the American Stomatological Association, Williams Club, New York City, December 20, 1932.

[2] Blum: *Journal of Dental Research*, 1930, x, p. 337; June.

other mucous membranes by the dermatologist. The general surgeon in case of serious accidents, the brain surgeon in trifacial neuralgia, and even the obstetrician where lesions of the gingiva appear during pregnancy, must be consulted in the interest of our patients. Finally we come to the roentgenologist when we suspect an expression of facial-bone lesions in other parts of the skeleton or a metastasis to the lungs or other parts. The importance of seeking advice and treatment, for our cases, from the specialist in radium and x-ray therapy is evident.

In attempting to practice our specialty in an ideal fashion, we must not be satisfied with taking care only of lesions for which cases have been referred to us. Every case, after consultation with whomever may be concerned, should be thoroughly examined as far as our field is indicated. The present-day tendency leans hopefully toward prevention, and therefore the patient's attention should be directed to the many benefits gained by the early recognition and care of many lesions. Furthermore, the periodic examination of the mouth, jaws and teeth, also by means of x-rays, pulp test and transillumination, must be explained to the fullest degree.

It seems apropos to say a few words about x-ray technique. Fourteen, twenty, or more *intraoral* films never complete an x-ray examination in our field. Extraoral films of the horizontal and ascending ramus, the so-called bite-film and other large intraoral views, the bite-wing film for the detection of pulp-stones or of decay, and other exposures suggested by individual requirements, are very often necessary.

In the paper referred to above, the following thought was expressed: "Especially would I like to emphasize my conviction that the oral cavity, on account of its accessibility, is a very fruitful field for the study of new growths in their incipiency, the results of which would be far-reaching." Unfortunately, our field requires a special pathologist, because we frequently deal with special tissue, some of which is only very rarely found in other parts of the body and gives rise to neoplasms peculiar to this region. In fact these and other difficulties stimulated in me some years ago the desire to interest pathologists in our special field. The oral pathologist should take part in clinical examinations and, if possible, should also be present at operations. Of course, we all believe in a thorough clinical examination, rounded

out and completed by laboratory tests and x-ray findings. However, it is the correlation of clinical findings, x-ray examinations, and pathological evidence, to which I want to call your attention, and in which I wish to interest you, as the one important means of increasing knowledge in our special field.

Today the oral surgeon cannot any longer claim that he is not a pathologist—meaning clinical pathologist—because, if he is really not, he has no moral right to practise his specialty, which in fact he cannot do intelligently nor to the benefit of his patients unless he is well trained to correlate clinical, oral, pathological evidence with his clinical and other findings. The dissemination of knowledge by exchange of thought and experience among oral surgeons and other medical and dental specialists, as well as among general medical and dental practitioners, at frequent conferences, where cases could be presented or reported and discussed freely and honestly by all participants, would practically reach the ideal, if the effort were supported by an institute where not only all types of pathological laboratory examinations could be made, but which would also act as a registry in the collection of material for the further study of any subject in our field.[3]

101 East 79th Street

[3] Such an institute—the New York Institute of Clinical Oral Pathology—has been established, with headquarters at 101 East 79th St., New York City, where further information is obtainable from the Secretary, Dr. Theodor Blum.— [*Ed.*]

A BRIEF STATEMENT OF THE CASE AGAINST FLUORINE IN WATER AS THE CAUSE OF MOTTLED ENAMEL

Production of Mottled Enamel Stopped at Oakley, Idaho, by a Change in the Water Supply

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Since the demonstration, about two years ago, that the presence of fluorine in potable water is associated with the occurrence of mottled enamel, the evidence to this effect has been steadily accumulating. In the drinking water from every mottled enamel district thus far tested, fluorine has been found to occur in amounts varying from 2 parts up to 16 parts per million of the water. Thus far the evidence indicates that 2 parts per million are sufficient to produce mottled enamel in any community in which water containing this amount is used for domestic purposes. In the surveys of many communities, it has invariably been found that where mottled enamel exists, the water supply contains upwards of 2 parts per million of fluorine; conversely, where mottled enamel does not occur, the water contains less than that amount, or none. In laboratory experiments on animals, in two state universities, fluorine compounds added to the diets invariably produced mottled enamel.

Fluorine is widely distributed in Nature, particularly in the first half-mile of the earth's crust, and is chemically the most active of the elements. Although occurring universally in animal and plant tissues, it is in no sense an indispensable element in the diet.[1] It is decidedly detrimental when included in more than extremely minute proportions. It has long been known to be particularly disturbing in its effects on calcified tissues, such as bones and teeth. Its occurrence in water is particularly associated with artesian wells

[1] Sharpless and McCollum: "Is fluorine an indispensable element in the diet?; *Journal of Nutrition*, 1933, *6*, 163; March.

and warm springs, both of which are derived from the more highly mineralized deeper portions of the earth's crust, and with streams that drain highly mineralized surface areas.

The most conclusive proof of the causative association of fluorine with mottled enamel has recently been obtained by the writer at Oakley, Idaho. Our examination there, in 1925, showed mottled enamel in every native child who had used the city water-supply during the years of enamel development. The water at that time, which contained 6 parts per million of fluorine, was derived from a warm spring. Owing to this prevailing defect of the enamel, a new water-system was substituted at a cost to the town of $35,000. Our examination, just completed, seven and one-half years after the change of water, showed that *the production of this enamel defect has definitely ceased. The new water at Oakley contains less than 0.5 part per million of fluorine.* The determinations of the fluorine contents of the specimens of waters used at Oakley were made at the laboratory of the Aluminum Company of America, New Kensington, Pa.

The practical value of this research is of extreme importance to any community that may be contemplating a new source for its water supply, or an addition thereto. A preliminary investigation of the fluorine content would determine whether the new water could be used without exposing future generations to the disastrous consequences of this defect of the teeth.

[This note supplements the report on this general subject by Dr. McKay in the proceedings of the American College of Dentists, Atlantic City, N. J., December 30, 1932; this issue, p. 139.—*Ed.*]

2 East 54th Street

AMERICAN COLLEGE OF DENTISTS

Scientific Proceedings of the First Meeting of a Dental Organization in Formal Association with the American Association for the Advancement of Science[1]

Atlantic City, New Jersey, December 30, 1932

Compiled by WILLIAM J. GIES, Ph.D., Sc.D., LL.D.[2]

Chairman of the Program Committee, School of Medicine, Columbia University, New York City

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[1] The three sessions of the American College of Dentists were held in the Chelsea Hotel. The chairmen at these sessions were successively Drs. E. H. Hatton (vice A. D. Black), L. M. Waugh, and U. G. Rickert. The general session of the Association in the afternoon, following adjournment of the second session of the College, was held at Haddon Hall, where the chairmen were Drs. H. T. Karsner and Alfred S. Walker. On the evening of December 29, a joint session of Sections L and N of the Association, the American College of Dentists, and the History of Science Society, at the Ludy Hotel, at which Dr. William H. Welch presided, was well attended by dentists, although there was no dental participation in the program on this occasion. The program, as arranged, included prepared discussions of all formal presentations excepting those by the Vice-Presidents for Section N (Drs. Park and Karsner) and by the chairmen of the first two sessions (Drs. Black and Waugh). Each of the prepared discussions has been included among the abstracts. Besides the prepared comment on each paper, there were also extemporaneous general discussions, but these were not recorded.

[2] Most of the abstracts have been prepared by those who presented the corresponding papers. All revisions have been verified by the authors.

I. Quotation from a General Report on the Proceedings of Section N (Medical Sciences) of the American Association for the Advancement of Science, at the Atlantic City Meeting[3]

Albert L. Midgley, D.M.D., Sc.D., Secretary, American College of Dentists

The initial appearance of dentistry, through the American College of Dentists, in affiliation with the American Association for the Advancement of Science, marks a new era in dental history, in that a scientific program in this subject was offered in conjunction with those of other organizations in the field of science. This alliance has more than a passing significance, for, as was emphasized by this meeting, the dental profession has an important part to play in the promotion of research. By no means content to confine their activities to the mechanical and esthetic phases of the profession, workers in dental science are keenly alert to the importance and value of its biological aspects. The fellows of the American College of Dentists are greatly appreciative of this opportunity to present a program at Atlantic City.—The program, which had been arranged by a committee of which William J. Gies (Columbia University) was chairman, included both theoretical and practical discussions on a high scientific and intellectual level. There were sessions on Friday morning, afternoon and evening [Dec. 30, 1932]. The program was opened by W. H. Park, vice-president for Section N. The need of dental research was discussed by E. H. Hatton (Northwestern University). The cause and prevention of mottled enamel, a preventable endemic lesion of the teeth, was discussed by F. S. McKay (New York), who showed how this disease points to a civic responsibility that closely allies dentistry with medicine and with the public health movement. A paper on the experimental production of typical dental caries in animals was given by Theodor Rosebury (Columbia University), who pointed out the importance of such experimental work in throwing light on the phenomena of tooth decay in man. J. L. T. Appleton, Jr. (University of Pennsylvania), presented a new plan for the treatment and management of infected teeth, suggesting avenues of thought that should lead to progress in the eradication of dental foci of infection and consequently in the elimination of related

[3] Cort and Midgley: *Science*, 1933, lxxvii, p. 151; Feb. 3.

disease conditions elsewhere in the body. An interesting discussion of dental and facial prosthesis, by V. H. Kazanjian (Harvard University), indicated a field of medico-dental study that should give hope and encouragement to those afflicted with discomfort, disability and deformity through accident to or disease of the tissues of face and jaws. Orthodontic problems and the use of x-ray silhouettes in tracing facial growth, by B. Holly Broadbent (Western Reserve University), diet as related to the development of osseous tissues of jaws and face in the American Eskimo, by L. M. Waugh (Columbia University), aids offered by scientific research toward the improvement of dental restorations, by Wilmer Souder (U. S. Bureau of Standards), morphological change in mucous membrane of edentulous areas of the alveolar process, by W. H. Wright (University of Pittsburgh), were other topics discussed. On Friday evening there was a dinner session, at which three constructive papers were presented, as follows: "Status of dental research," by U. G. Rickert (University of Michigan), "Microscopic research on periodontal diseases," by Rudolf Kronfeld (Loyola University, Chicago), and "Field studies of human tooth decay in primitive districts providing immunity," by Weston A. Price (Cleveland, Ohio). On Friday afternoon, at a general session of the American Association, R. W. Bunting (University of Michigan) gave an interesting lecture on recent developments in the study of dental caries.

II. Index of Names of Participants, and Sequence Numerals of the Corresponding Abstracts on the Succeeding Pages

Appleton, 7; Batson, 10; Black, 2; Broadbent, 12; Bunting, 19; Churchill, 4; Enright, 6; Foley, 5; Hatton, 2, 8; Hellman, 13; Ivy, 10; Karshan, 5; Karsner, 18; Kazanjian, 9; Klein, 25; Kronfeld, 22; McKay, 3; Messner, 15; Miller, 23; Park, 1; Price, 24; Rickert, 20; Rosebury, 5; Schuyler, 17; Souder, 14; Walker, 21; Waugh, 11; Wright, 16.

III. First Session: Morning; Abstracts 1–10

1. introduction

William H. Park, M.D., Sc.D., LL.D., New York University, New York City; Vice-President for Section N, American Association for the Advancement of Science

It is a great pleasure to me as the Chairman of Section N, the Medical Section of the Association, to welcome you. More and more the

dental profession is being considered a part of medicine, its work in preventive medicine being especially important. The members of each specialty, whether it be in diseases of the eye, chest, oral cavity, or any other, have an important part. In addition in curative fields, each specialty has its own special training and experience. It certainly is an advantage for all of us to develop this common association, which we have in our interests and in the great purpose of making life more efficient and more attractive.

Recently the New York Academy of Medicine published a volume on the "Outline of Preventive Medicine for Medical Practitioners and Students." Two of the most important chapters treat the prevention of disease and the correction of malformations in the various parts of the oral cavity. These were by your eminent fellow members, Dr. Henry W. Gillett and Dr. Henry S. Dunning.

Some of those interested in the present meeting have suggested the following plan: the members of the dental and medical professions would have sub-sections of Section N; possibly there would be a third sub-section of those interested especially in preventive medicine. Each of these sections would have a Vice-Chairman, and all three would be under the general Vice-President for Section N.

I hope these meetings may become so valuable that the dental profession will join with the medical profession in making Section N a meeting place for the specialties dealing with the prevention of disease, and the lessening of the effects of disease processes that have already started. I also hope that this first meeting will prove of such interest to those attending it that all of you will vote to continue joint meetings at the annual sessions of the American Association for the Advancement of Science.

2. THE FIELD OF DENTAL RESEARCH

Arthur D. Black, A.M., M.D., D.D.S., Sc.D., Northwestern University, Chicago, Ill.; Chairman of the first session[4]

Statement of the progress of research in the dental field and the various agencies currently engaged. About $50,000,000 have been

[4] In Dr. Black's unavoidable absence his paper was read by Dr. E. H. Hatton, B.L., M.D., of Northwestern University, who also took Dr. Black's place in the chair at the morning session.

given to dental education and children's clinics in research during the past twenty-five years. The amount devoted to research is difficult to estimate, probably about $100,000 annually. The American Dental Association has made grants of more than $300,000 since 1913. A list of 107 problems in the dental field, classified according to the science departments in which they should be studied, was presented. These suggest need of coöperative effort and better guidance. As health promotion gains momentum, no other health service offers greater opportunity than dentistry.

3. MOTTLED ENAMEL: A PREVENTABLE ENDEMIC LESION OF THE TEETH THAT PRESENTS A NEW PROBLEM IN CIVIC RESPONSIBILITY

Frederick S. McKay, D.D.S., New York City

About twenty-five years ago, dentists in a city in a western state observed that many persons exhibited a very disfiguring condition of the teeth. This consisted of a dark brown or almost black discoloration over the upper front teeth that otherwise were marked by irregular grayish white areas, and in severe cases by pits and rough corroded areas. This condition affected every tooth in the mouth and has come to be known as "mottled enamel." Nothing was known about the cause of this condition; nothing resembling it had ever before been reported. It occurred only in children born and raised in that district, and every native person was afflicted. In persons moving into that district, the teeth already formed were not affected, but any teeth formed within the district were affected. This injury to the teeth, consisting of imperfect calcification of the enamel, was permanent, never being repaired by natural means. These conditions have been found in afflicted districts in Arizona, Arkansas, California, Colorado, Idaho, Illinois, Minnesota, New Mexico, North Dakota, South Dakota, Texas, Virginia, Kansas, North Carolina, Oregon and Washington, and foreign countries.

The evidence in each of these various places indicated that something of local origin was the cause, and it eventually became evident that it was the drinking water. Up to that time no defect of the teeth had ever been associated with water. It was difficult to believe that waters so generally satisfactory in every other way, and apparently so

pure and agreeable to use, could be responsible for this defect. Repeated analyses failed to indicate anything significant until an examination of water from one of the afflicted districts, by H. V. Churchill in the chemical laboratory of the Aluminum Company of America for another purpose, revealed the presence of fluorine (fluoride). Fluorine does not commonly occur in water, but was known to produce changes in teeth and bones of animals in laboratory experiments. Lately it has been found that wherever more than 2 parts per million of fluorine are contained in drinking water, mottled enamel occurs; where there is less than that amount, mottled enamel is absent. Recently, mottled enamel was reproduced in the teeth of rats, by Margaret Cammack Smith at the University of Arizona, by feeding concentrated water containing fluorine from an afflicted district, thus establishing convincing proof that fluorine is the injurious agent.

Any community, therefore, that supplies water containing upward of 2 parts per million of fluorine, for domestic use, is directly responsible for this disfiguring defect in the teeth of its children. For the prevention of this condition in the afflicted districts there is no alternative except to discard fluorine-bearing water supplies, and substitute others that are fluorine free. This has lately been done by two communities in this country. The results of the change will not be obtainable until about six or seven years afterward, when the teeth formed subsequent to the change of water will have erupted. These are the first instances in the history of dentistry where communities have changed their water supplies in order to prevent a defect of the teeth of their inhabitants. [A later note on the prevention of mottled enamel, by a change in the domestic water-supply at Oakley, Idaho, is published by Dr. McKay, on page 133 of this issue.—*Ed.*]

4. DISCUSSION OF DR. MCKAY'S PAPER

H. V. Churchill, B.A., Aluminum Research Laboratories, New Kensington, Pa.

A wiser mind than mine has said: "Discovery comes whenever trains of thought or pieces of information originally separate are seen to illuminate and explain each other." The humble contribution of your speaker was the illumination of the problem of mottled enamel by the demonstrated fact that in all localities studied wherein mottled enamel is endemic, the water supplies contain more than 2 parts per million of fluorine. The essential correlation of fluorine in drinking water and mottled enamel has gone for-

ward rapidly until today no competent observer will deny the strong likelihood of a causal relation between the two facts of fluorine above certain concentrations in potable water and mottled enamel. The acceptance of fluorine as the causative agent in mottled enamel immediately sets up two major problems. (a) What is the mechanism of the influence exerted by fluorine? (b) How can the civic agencies which are responsible for water supplies provide water of safe fluorine content?

Dr. McKay's paper presents some putative implications which would serve to guide research as an approach to the problem. As McKay points out inferentially and explicitly, the defect is essentially one of structure and not one of composition. This would seem to the writer to be of profound significance. Naturally as a metallurgical chemist I must draw my examples from my special field of knowledge. In alloying work, there are two basic reasons for adding an alloy ingredient to a base metal. We may make an alloy addition because the presence of that alloying ingredient in the alloy structure imparts desirable properties of strength, hardness, or other qualities, to the resultant metal. We may make alloying additions not because the presence of the additive material is desirable, but because by its presence it may profoundly affect the structure of the metal by interference, or at least influence upon solidification or crystallization phenomena. For example, an alloy of aluminum with 13 percent of silicon has a structure of coarse primary silicon aluminum eutectic somewhat brittle, and not specially strong. If however to the molten metal we add 0.03 or 0.04 percent of metallic sodium, and then permit the metal to solidify, we find the silicon finely dispersed throughout the alloy, and we have a metal of improved ductility and of desirable strength. The silicon was added because we desired the particular properties imparted by its presence. We add sodium not because we want it to be present, but because it prevents crystal nuclei from growing into coarse plates. In other words, we want silicon for what it is, but we want sodium for what it does. I suspect the rôle of fluorine to be like that of sodium in the alloy. In some way or other it functions to disturb or influence the way in which the real structural material of the teeth is built up into teeth. To put the matter more simply, the writer does not believe that a chemical examination of mottled teeth will reveal excessive or deficient amounts of tooth enamel or structural components.

If we grant the soundness of McKay's conclusion that mottled enamel is a structural phenomenon occurring during tooth formation prior to eruption, it would be interesting indeed to compare enamel structure statistically in localities where fluorine is absent from the water supply, with enamel from localities where fluorine is present to the normal amount found in American

cities (less than 2 p.p.m.). Perhaps it would be revealed that there are degrees of this dental lesion. Perhaps any fluorine in the water supply has an effect, but the defect becomes severe enough to be noticed only when fluorine reaches a critical concentration. Perhaps fluorine is not a normal constituent in human tissues and structures, and is present only accidentally and because the body is habituated to it. That goes somewhat afield however.

Now we are confronted with the apparent fact that mottled enamel is endemic in localities where the fluorine content of the water supply is above 2 parts per million. What are we going to do about it? From a water-treatment standpoint there is apparently little to be hoped for at the present time. The known chemistry of fluorides affords little hope of devising precipitation methods that will remove fluorides economically. That, however, is definitely a problem for the water chemists. The other remedy is the abandonment of existing water supplies in favor of fluorine-free supplies. In many cases this may involve tremendous expense. One thing that could be done is to insist that, when new supplies are brought in to supplement or replace old sources, fluoride content be set up as a criterion of water quality along with those other criteria now used by water specialists. There is considerable current propaganda for the provision of soft water to municipalities on the ground that this would enormously cut the soap bill of the American people. If we are willing to spend y dollars to save x pounds of soap, it would seem that we might be willing to spend even $2y$ or $3y$ dollars to prevent the hideous disfigurement shown by Dr. McKay in his slides.

My interest in this problem was first aroused by the work of McKay and Kempf in a mining community owned by the company I represent, the Aluminum Company of America. An interesting fact in this connection is that, while the Company did not suspect any causal connection between the water supply and the mottled enamel which was endemic in the village, luckily, before McKay's survey, it had abandoned the old fluorine-bearing water supply in favor of other water which happened to be free from fluorine. There, as the new generations of children come, is an opportunity to verify the findings thus far made.

The civic significance of this work on mottled enamel has been pointed out by McKay. Certain states are now making state-wide surveys. Particular communities are making studies of their individual problems. Until the water-treatment experts can devise a means of fluorine removal or diminution, replacement of fluorine-bearing water supplies with fluorine-free water supplies is indicated. If this is not done, then the responsibility for this disfigurement of teeth must be borne by those who knowing the cause do nothing about it.

5. THE EXPERIMENTAL PRODUCTION OF TYPICAL DENTAL CARIES IN ANIMALS, AND ITS VALUE FOR THE STUDY OF DECAY OF TEETH IN MAN[5]

Theodor Rosebury, D.D.S., Maxwell Karshan, M.A., Ph.D., and Genevieve Foley, M.A., Columbia University, New York City

Much of the confusion in the field of experimental dental caries in rats seems to depend upon the failure of many workers to distinguish between the several varieties of tooth destruction to which the rat is subject. Some of these varieties depend upon anatomical peculiarities of the rat molar that have no analogue in human teeth, and are therefore essentially unrelated to any type of dental caries in man. One such lesion we have described begins mechanically by fracture of a defectively calcified tooth under the impact of dense food particles in mastication. Although it differs in mode of causation from fissure caries, this lesion, when fully developed, is not often distinguishable from well-developed cavities arising through fissure caries.

We have described the occurrence of dental caries of molar fissures in young rats on experimental diets. This type of decay is closely similar in course and appearance to caries of fissures in human molars. Such decay may be produced and prevented at will by altering only the particle size of uncooked rice in the diet. No dental caries occurs when cooked rice replaces uncooked rice in the diet. It follows that the physical character of certain dietary ingredients determines the production of dental-fissure caries in rats. These lesions may be produced on diets adequate in all essential nutrient substances, in the

[5] Quotation from "Science news: Some papers presented at the Atlantic City meeting of the A. A. A. S.": *Science*, 1933, *77*, 28; Feb. 3.—"Dr. Rosebury and his associates at the College of Physicians and Surgeons, Columbia University, have found that they could produce or prevent dental-fissure caries in rats at will by changing the size of the particles of uncooked rice in the rat diet. No tooth decay occurred when cooked rice replaced uncooked rice in the diet. The type of tooth decay thus produced is so much like the dental caries of the fissures or crevices of human teeth that it is assumed that the same causes produce the condition in man and in rats. The tooth decay may be produced in healthy, well-grown rats that are on an adequate diet with plenty of vitamins, minerals and other food essentials, and that have teeth free from structural defects. Rats on adequate diets, however, have less tooth decay than rats on deficient diets. Dr. Rosebury pointed out that there are several kinds of tooth decay to be found in rats. Not all of them are comparable to human caries. Failure to distinguish between the different types of rat caries has caused much confusion in experimental studies of tooth decay in the rat."

presence of normal growth and health, and in teeth without appreciable structural defect, and are accordingly not dependent upon any dietary deficiency, nor upon any appreciable departure from the general constitutional well-being. The incidence of dental caries in rats is, however, reduced on adequate diets as compared with deficient diets. The significance of this finding is as yet in doubt. Possibly certain dietary deficiencies augment or accelerate the process, without in themselves determining ultimate susceptibility, or, since alterations in the diet that make it adequate also change its physical character, the caries-producing potency of the diet may thus be reduced. Experiments now under way will, we hope, throw light on this matter.

6. DISCUSSION OF THE PAPER BY ROSEBURY, KARSHAN AND FOLEY

J. J. Enright, Ph.D., Mellon Institute, Pittsburgh, Pa.

The main investigational advances reported by Dr. Rosebury are these: (1) He has confirmed the work of Shibata in producing, in rat molars, carious lesions simulating typical human caries; (2) he has substantiated the results of Hoppert, Webber, and Canniff in relation to the significance of the size of food particles in caries production; and (3) he has shown that caries can be produced in the rat whether certain deficiencies in diet are present or absent, but that there is a reduced incidence of decay on the more adequate diet. Dr. Rosebury's report is also of value in that it emphasizes the necessity for differentiation of types of lesions in rat molars, a lack of consideration of which by certain earlier investigators has been responsible for some of the confusion resulting from nutritional investigations in this field.

The most important part of Dr. Rosebury's paper, as far as I am concerned, has to do with the interpretation of the experimental results. Dietary studies during the past ten years have certainly occasioned misunderstanding among dentists respecting the causes of tooth decay. The principal reason for this confusion has been the many unjustified inferences from the observations in several nutritional investigations. It is most encouraging to hear Dr. Rosebury report that, because animals fed on diets deficient in mineral salts, protein, and vitamin D developed caries, it does not necessarily follow that these deficiencies are intimately connected with the etiology of the observed lesions. A study of the literature has revealed descriptions of experiments in which caries occurred in animals on diets having these deficiencies, and also of experiments in which no caries occurred on diets with similar deficiencies. It is clear, because of the presence of other

pertinent variables in the experimental set-up, that neither conclusion can be interpreted to mean that the said dietary deficiencies are or are not causative of dental caries. The contribution by Hoppert, confirmed by Rosebury, indicates that we are beginning to learn about one relevant variable, namely, size of food particles. If such information continues to accumulate, we shall soon be able to design dietary experiments with rats in which we can produce caries at will, irrespective of the presence or absence of certain other deficiencies whose importance is now being emphasized.

The problem of dental caries is complex when viewed in the light of its evident active and passive causative factors. It therefore seems constructive to suggest that at least three essential conditions should be weighed by investigators in interpreting their experimental results, to clarify knowledge in this field, as follows: (1) The observed experimental results should be correlated with known facts concerning the clinical disease, and the histology of the dental tissues. (2) Dietary influences may operate in a constitutional or local environmental manner, or both. (3) Descriptions of experiments should indicate whether the decay under consideration is caries of enamel, or dentine, or both. These two tissues being different, statements relating to one may not apply to the other.

Although I have no doubt that the use of the rat will help us to solve the problems of dental caries, I am not pessimistic regarding the use of human subjects in well-controlled experiments, not only on prevention but also on cause. Well-controlled observations on human beings will be necessary to prove beyond a doubt the value of any procedure to prevent caries. Within the field of etiology, investigators who maintain the importance of vitamin C will likely be unconvinced by experiments on the rat because of its known unsuitability for tests in which this factor may be concerned. Observations based on suitable experiments and tests, on humans, would plainly be the source of the last word on the causes of this malady. It would not be at all inhuman or undesirable to gather the youngest groups of individuals in a large penitentiary, for example, and run experiments planned from the results of animal experimentation like that reported by Rosebury. In such an institution a high degree of control, and the opportunity for reward for cooperation by test subjects, would be easily attainable. Such tests could easily be devised to work to the mutual advantage of dental science and the test subjects.

7. A CONSIDERATION OF SOME QUESTIONS BEARING ON THE STATUS OF THE PULPLESS TOOTH

J. L. T. Appleton, Jr., B.S., D.D.S., University of Pennsylvania, Philadelphia, Pa.

The clinical classification of pulpless teeth, and the question, why is the pulpless tooth in bad repute?, were discussed. The problems considered were these:

(1) Of 100 patients with pulpless teeth, how many will eventually suffer serious extra-oral damage from retaining those teeth?

(2) Can bacteria be present in periapical tissues of pulpless teeth without doing harm?

(3) Is the x-ray-*negative* pulpless-tooth less or more likely than the x-ray-*positive* pulpless-tooth to give extra-oral trouble?

(4) What are the bacteriological findings in periapical tissues of pulpless teeth, and of teeth with clinically normal pulps?

(5) Does the mere loss of the pulp *per se* lower the resistance of periapical tissues to lymphogenous or hematogenous infection?

(6) Why, in some cases, do bacteria or their products escaping from a periapical lesion succeed in establishing a secondary lesion?

(7) Is it possible, in a given case, to tell with confidence whether a pulpless tooth is actually or potentially a source of danger, or whether it may be retained with negligible hazard to the patient?

Objectives of any and all root-canal technics were indicated. Five criteria were proposed by which the efficiency of a proposed method of root-canal treatment should be judged. No method yet advocated has systematically and adequately been subjected to these criteria.

8. DISCUSSION OF DR. APPLETON'S PAPER

Edward H. Hatton, B.L., M.D., Northwestern University, Chicago, Ill.

Dr. Appleton has discussed what is popularly called the dead, or devitalized, tooth. His term—"pulpless"—is scientifically correct, and its use is to be preferred to any other name. One cannot question his conclusion that "the pulpless tooth is in bad repute" and that "bacteria in the periapical tissues are in some cases responsible for extra-oral damage." It is also agreed that "the clinician wants to know whether this relationship is usual or exceptionable." And yet "let us recall that the percentage of pulpless or

periapically infected teeth which become responsible for extra-oral conditions is as yet undetermined." And "we do not know whether or not a pulpless tooth is always a menace to health." The evidence at hand relating to the management of the pulpless tooth comes from four sources: the clinician, the bacteriologist, the roentgenologist, and the histologist. The members of each of these four groups are likely to be prejudiced by the investigations in their own fields—even by different groups in the same field. This probably accounts for the wide divergence of existing opinion.

Dr. Appleton's report deals with the conclusions reached after long discussion by a group that includes members from all the departments interested in the pulpless tooth, it represents all the shades of opinion that have been suggested in the preceding paragraph. The conclusions as such must have more weight than if they were those of a single individual. However, their conclusions and their plan are not wholly acceptable to themselves, for they say: "Most certainly the resultant policy is not satisfactory because of crucial gaps in our knowledge, and assuredly it is not the last word." Perhaps this would be an excellent statement with which to end the discussion. One cannot, however, overlook the fact that the bad repute of the pulpless tooth has been built upon the results of bacteriological investigations, and that there is a certain degree of antagonism between the conclusions reached by the bacteriologist on the one hand, and the histologist, the roentgenologist and the clinician on the other. It is to be hoped that these differences of opinion are capable of solution, and that this group as well as others may succeed eventually in devising a plan that will be universally acceptable because of the finality and validity of the evidence submitted.

9. DENTAL AND FACIAL PROSTHESIS, AND ITS RELATION TO SURGERY OF THE FACE AND JAWS

V. H. Kazanjian, D.M.D., M.D., Harvard University, Boston, Mass.

Medicine and dentistry are both approaches from two different angles to the same great problem. No more striking example of this interrelationship can be found than in my own field where the most satisfactory results are obtained from an intelligent coördination of prosthesis and plastic surgery. Prosthetic appliances in relation to restorative surgery have the following functions: Immobilization of the parts in jaw fractures; prevention of adhesions and scar tissue in extensive lacerations; improvement of speech and restoration of facial

contour in cleft palates; restoration of nose, orbit and ear; and provision of artificial support to tissues when bony framework of the face is destroyed. Prosthesis cannot always replace surgery; the two should supplement each other.

In the field of fractured jaws a prosthetic appliance may be of great assistance, especially where ordinary methods, such as external bandaging, are inadequate. Splints are designed to use existing teeth and alveolar processes as points of anchorage, and to re-establish normal occlusion as a fundamental point in the process of immobilization. In cases of extensive laceration, temporary appliances may be inserted to prevent adhesions and formation of scar tissue—conditions which, if neglected, would materially hamper normal prosthetic restoration. Occasionally preliminary plastic surgery is needed to provide for these temporary appliances. In the long run temporary measures contribute much to a satisfactory outcome. Modern methods of treating cleft palate are largely surgical, but subsequent developmental changes, including speech defects, nasal deformities, irregularities of teeth, and distortion of maxillary arches, imply need for coördinated prosthetic restorations or appliances. Orthodontists often overlook related deformities of lip and nose by the habit of thinking of their cases in terms of individual tooth movement. In cases of malignant disease, where treatment involves extensive loss of both hard and soft tissues, prosthetic restorations serve two purposes: (*a*) Where loss of tissue has been extensive, nose, orbit and ear may be restored prosthetically with excellent results. (*b*) Where extensive losses of mandible and maxilla are involved, the restoration may serve to support soft tissues. Only by intelligent coördination of effort between surgeon and dentist can the most satisfactory solution of this type of restorative problem be achieved. It is my hope that in the future, surgeon and dentist will have an increasing appreciation of the other's field of activity. (Eight short case-histories were included.)

10. DISCUSSION OF DR. KAZANJIAN'S PAPER

Robert H. Ivy, M.D., University of Pennsylvania, Philadelphia, Pa.

Dr. Kazanjian possesses the happy but rare combination of surgical ability and mechanical skill. He is able personally to treat cases of facial reconstruction from both standpoints. Most of us have to be content with handling one or the other part of the problem. In my own work I am ob-

liged to enlist the aid of someone else in cases where prostheses are required, excepting fixation of a majority of jaw fractures. Among those collaborating on the prosthetic side of the work are Dr. F. A. Fox of the Evans Institute; Prof. O. V. Batson of the Department of Anatomy, University of Pennsylvania; and the Dental Staff of the Walter Reed General Hospital, Washington, D. C. Dr. Kazanjian's paper covers a wide field, and in the time at my disposal I am able to touch on only a few points in discussion.

I am entirely in accord with Dr. Kazanjian in regard to the orthodontic and prosthetic management of cleft-palate cases. Regarding the major defects of facial tissues, particularly of the nose, I believe the first choice in restoration should be surgery, with prosthetic methods reserved for cases where surgery is not adaptable either from general debility of the patient or lack of suitable tissues. In many cases a combination of the two methods gives the best results. In one type of case I believe definitely superior results are obtained by prosthesis; namely, total or almost total absence of the external ear. In absence of the nose, provided tissues are available, very satisfactory restoration usually can be obtained by surgical means alone.

Dr. Kazanjian has a preference for vulcanite as a prosthetic material. Other substances have been suggested for external facial prostheses, such as gelatin-glue-glycerin mixture, which perhaps has advantages under certain conditions. When made and colored properly a prosthesis of this material has a more life-like appearance, and a consistency resembling that of living flesh. It has the disadvantage that it is affected by moisture, and has to be renewed at frequent intervals. An intelligent patient can be given a plaster or metal mould of the part, and taught to make these renewals himself. (Prof. Batson gave details and showed specimens of this material. A few slides illustrated the use of prosthesis for restorations of nose and ear.)

IV. Second Session: Afternoon (2–4:30); Abstracts 11–17

11. Influences of Diet on the Development of the Jaws and Face of the American Eskimo[6]

Leuman M. Waugh, D.D.S., United States Public Health Service; Columbia University, New York City; Chairman of the second session

Mummery, about 1887, in reporting studies of the teeth of various races, stated that the Eskimo, a people of small stature, had the largest

[6] Earlier reports relating to dental caries (1928–31), and to face and jaws (1932), were published in the *Journal of Dental Research:* 1928, viii, p. 428; 1930, x, p. 387; 1931, xi, p. 453; 1932, xii, p. 426. The complete study will be published by the U. S. Public Health Service.

jaws and best teeth of any known race. This statement was found to be true of the Eskimo in Labrador, as well as in Arctic Alaska, so long as he lived the primitive nomadic life of his ancestors. However, when he adopts white man's diet and mode of living, there is startling deterioration even in one generation, both in size and strength of the jaws, and in regularity of the teeth. *The change in food is the determining factor.* The ancestral diet consisted of proteins and fats almost exclusively. In some settlements at times the proteins amounted to 65 percent. The diet included the red meats of seal, walrus, sea lion, whale, balooga, caribou, reindeer, bear, trapped animals, birds—also fish of various kinds—which were hung in the sun to "cure," becoming dry and hard, and requiring much rugged chewing when eaten. In winter, they were frozen solid, and eaten without preparation except thawing. This rugged chewing of food is beyond question the great factor in jaw development, as the children have little other food after weaning.

Newly erupted teeth have cusps, grooves, and fossae, as deep and well formed as those of white children; but, because of the heavy mastication, the occlusal surfaces soon become so much worn that, at 12 to 14, they are quite noticeably flattened. This is probably due in part to grit picked up when the fresh meat and fish are thrown on the rocks prior to "curing." As the occlusal surfaces become abraded, still greater muscular effort is necessary for mastication. All this undoubtedly stimulates growth of the jaws and size of the face. Not only do the dental arches assume a larger regular outline, with a strong tendency to assume the inverted letter-U form, but the body of the jaws and the alveolar process are very thick and strong. The latter is a transitory structure, builded as the tooth erupts, and becomes resorbed following the loss of the tooth. For this reason the author recognizes that this structure responds to acquired influences much more readily than the body of the jaws. The degree to which this occurs should be of special interest to the orthodontist, in his effort to stimulate bone growth without appliances, on the sound physiologic principle that "the use of an organ determines its strength," that "function begets structure," and that "bone is under the dominance of actuating muscles." Exercises properly selected and persistently performed by the patient must be helpful in the stimulation of jaw de-

velopment. The Eskimo also use their teeth in softening the raw, dry hides from which they make their muk-luks—native boots—clothing, harness, etc., etc. It is the rule that at 16 or over, the teeth are much worn, often to half the original length of the crowns; at 25 to 35, they are often worn almost to the gum. This is more noticeable in women, who "make" the equipment.

In natives, at 24 to 40, a prominent bulging-ridge is frequently noticeable on the labial and buccal surfaces of the alveolar process over the *cervical* half of the root, and a more prominent one, about one-fourth inch wide, on the lingual side of the lowers along the *apical* half of the roots. This the author regards as adventitious alveolar process, due to excessive and persistent chewing. This full, almost bulging, alveolar process is suggestive of that seen in such lower animals as the ape. In marked contrast to the foregoing is the lack of this thick, strong, development in the jaws of natives who get so called "white man's food" from prospectors, miners, traders, and stores. The Eskimo, especially the young, prefer sweet, soft food that requires little chewing; and, when thus fed, the children of rugged-jawed parents have very noticeably smaller and less strongly formed jaws. Under these conditions, which are unnatural for them, irregularity of the teeth becomes as extreme as in American children, and occurs in from one to two generations.

The foregoing gives further support to the author's earlier conclusion that "the American Eskimo is veritably paying for his civilization with his teeth." (Forty-five lantern illustrations were used in the presentation.)

12. THE ORTHODONTIC VALUE OF CEPHALOMETRIC STUDIES IN FACIAL GROWTH WITH THE ROENTGENOGRAPHIC CEPHALOMETER: THE USE OF X-RAY SILHOUETTES IN TRACING FACIAL GROWTH

B. Holly Broadbent, D.D.S., Bolton Fund and Western Reserve University, Cleveland, Ohio

The application of suitably oriented x-ray pictures to trace internal as well as external changes in the faces of growing children is one of the most interesting, valuable, and scientific advances of dentistry. Calipers have served well for a long time to measure the relationship of the

facial profile; that is, of chin, nose, front teeth, etc., to the rest of the head. (Now it is possible to register nearly all of Nature's handiwork at the foundation of beautiful facial features.) The attractive curves of a baby's face are seen, with x-ray eyes, gradually to lengthen out, and be moulded, by the changes taking place underneath the skin into the ugly-duckling features of childhood and adolescence, and, finally, to take on the delicately chiseled lines of young adulthood. This takes twenty years in a single person, but fortunately is disclosed in less than three years through a group study of 3000 children ranging, in age, from birth to young adults. These groups are then pieced together to complete the picture.

By this new method, the x-ray pictures taken by different operators can be made identical. Subsequent pictures can be taken with the assurance that the exact relations of the original pictures have been maintained. Then from the resulting pictures of a developing child, in the study of individual growth, any subsequent picture superimposed upon the original picture will give a measure of change in the developmental growth of the face. Tracings made from a series of x-rays, when photographed in succession with a motion picture camera and projected on the screen, give an animated picture not only of normal growth of face and head but also of changes that result in crooked teeth, deformed jaws, and ugly facial features. These studies are most valuable to the orthodontist, to whom children are usually taken during teething stages after the first few baby teeth are shed, and the first of the permanent ones appear in their places. A careful diagnosis is then most important, for the x-ray studies and measurements of the internal face are demonstrating that ugly-duckling stages appear *temporarily* in the dentition during normal development; that these are not 'crooked teeth;' and that they call for no mechanical interference.

Usually more than a single examination of teeth and jaws is necessary to determine the path of development, whether normal or abnormal, and should include measurements based on landmarks outside the face itself. These x-ray tracings of the cranial base and face have revealed the significant fact that the ear-hole is really a part of the face, and moves downward and backward as the face grows downward and forward. X-ray silhouettes of normal faces of healthy growing children serve as gauges of disharmonies in growth of developing faces.

Superimposition of the x-ray silhouette of a child having a malformed ugly face and crooked teeth, on these gauges, indicates the defect and changes necessary in orthodontic treatment.

13. DISCUSSION OF DR. BROADBENT'S PAPER

Milo Hellman, D.D.S., American Museum of Natural History, New York City

Dr. Broadbent has presented a technique for the study of facial development that, in refinement, leaves little to be desired. Anyone who has struggled with the problem will recognize the value of its practical application. It should, however, be emphasized that standardization of a procedure depends not only upon uniformity in results by the same person in any laboratory in repeated operations, but also upon uniformity in results by different persons in different laboratories in the same procedure. The available evidence tends to demonstrate fulfillment of the first requirement, while that of the second is yet to be shown. Cruder methods for similar studies have been used before, but no attempt has hitherto been made to standardize technique. Thus, measurements of the external dimensions of the face by means of calipers (spreading and sliding calipers of the anthropologist, and Todd headspanner) have been used for similar purposes. While methods of measuring with these instruments assume a standardized aspect, the technique really depends upon the skill of the individual using them. The results are therefore a matter of personal equation. But, in spite of these difficulties, it has been possible by means of these crude methods to point out the gross features involved in the development of face, jaws, and dentition.

In my studies of development of the face, I had occasion to point out that in transition from infancy to adulthood the face undergoes marked and significant changes, consisting of increase in size, change in proportion, and adjustment in position of facial features. By these means it was also possible to show that there is considerable variability in faces not only with dentitions in malocclusion, but also in normal occlusion. Another significant fact brought out in my studies was that certain facial features, presenting an apparent disturbance in occlusion during a period of retardation, tend to correct themselves in the course of development during a subsequent period of acceleration. A fact of no less importance was the observation that tendencies in facial growth associated with malocclusion are rarely overcome by orthodontic treatment, despite the fact that the occlusion of the teeth has been changed to normal.

Although it was possible to shed light on the problem of facial growth in relation to occlusion of the teeth by the use of crude implements, it is very

encouraging to see the perfection of an equipment that is bound to do more. The details involved in the mechanism of facial growth, as pointed out so clearly by Dr. Broadbent, are features discoverable only by such refined technique as he demonstrated. The value to the scientific phase of orthodontia is paramount even to our appreciation of their significance.

14. SCIENCE AIDS IN IMPROVING DENTAL RESTORATIONS

Wilmer Souder, Ph.D., National Bureau of Standards, Washington, D. C.

Dentists striving for perfection. Just as perfection of root-canal work would reduce demand for the services of the exodontists, so perfection of dental prophylaxis would reduce demand for the services of operative specialists. The present subject comes second along that rough and circumscribed road where we encounter the difficulties of decay, restoration, recurrent decay, pulp involvement, canal treatment, abscess, impaired health, extraction, artificial restoration. Everyone realizes that with development of perfected methods and satisfactory accommodations at any of these stations, we shall see the road end at that haven. Since our station (restoration) comes early in the journey, we may perhaps be excused for insistence on its fundamental importance. The name of the station expresses correctly the hopes of the patient when first he visits the dentist. Today, through the application of scientific research, the dentist comes nearer attaining this ideal than at any time in the previous history of the race.

Nature does not favor the dentist. Few afflictions are more peculiar or subtle than dental decay . Compared with a local skin infection, a broken bone, or even a deep-seated abscess, tooth decay requires unusual attention and skill. We may possibly allow a skin infection to go without treatment, and discover a few days later that it has disappeared. Specialists may adjust the position of a broken bone, permit it to rest a few weeks, and then find it as strong as ever, and the patient free from further inconvenience. Surgeons may excise a deep-seated abscess and, except for sterile dressings, abandon further attention to the case, and a few months later note complete recovery. We have skillful surgeons, and are always anxious to secure their services when afflicted. However, we know that Nature for the surgeon (like charity for the pilgrim) is a wonderful ally, and may cover a multitude of inaccuracies. The dentist cannot count on this unusual coöperation

from Nature. If he should remove all decay from the teeth of his patients and could keep the cavities sterile for a few days, and then dismiss these patients without further attention, he would be expelled from his profession. Not only must he remove infections, but he must seal the cavities against future infection; and, without assistance from Nature, must seal them with materials that will *function* like the original structure. This perfection has been developed over a period of approximately 75 years through constant, intensive research.

Bureau of Standards coöperates. Science had repeatedly recorded its verdict on amalgam and a few other materials when the Bureau entered the field of dental research in 1919 at the request of the War Department. The Bureau at that time tested popular brands of amalgam, and rendered a confidential report to the War Department, which enabled it to purchase safe amalgam alloy. A public report was made describing methods for the accurate testing of amalgam. Every progressive amalgam manufacturer has since adopted the test methods described in that report. A more elaborate program was gradually developed, beginning in 1922. It included permanent contributions on the physical properties of dental materials. In 1928 the Research Commission of the American Dental Association established a coöperative fellowship at the Bureau that concentrated attention on practical phases in the dentist's laboratory.

Patients want permanent restorations. Patients are anxious to have restorations that will serve them perfectly during the remainder of their lives. They expect the dentist to give them a commodity superior to that made by Nature; for the natural tooth has failed. There are often, however, valid reasons for such expectations. Laymen are repeatedly referred to gold-foil or amalgam fillings which, after 50 years of service, are without apparent defect. The question asked by the public is: "Why are not all restorations permanent restorations?" It is clear that *some dentists* have been able to place in *some mouths* restorations made from *some materials* that give perfect satisfaction. This fact gives us three items for attention: (*a*) The manufacturer with his product. (*b*) The dentist with his operative ability. (*c*) The patient with his nutritional balances and habits. I am not competent to discuss the third item.

Safe materials necessary. It is impossible to do satisfactory work

with defective materials, or by defective technics. Here we find the two causes of most failures in dental work. Thousands of amalgam fillings have been replaced, free of charge, because they did not last twelve months. Inlays, bridges, silicate cements, and countless other restorations have been replaced without cost (?) to the patient, but with discouragements, possible humiliation, and loss of patients, to the dentist—all because of inherent defects in materials. An amalgam alloy that shrinks on hardening, or flows under the stresses of mastication, cannot protect a tooth for an extended period.

The work at the Bureau of Standards is a continuation and extension of G. V. Black's methods, using modern instruments of greater precision, and also extending the field to include additional dental materials. Ten years after Black's researches were available, we tested fifteen amalgam alloys including practically all popular brands and found only four safe for dental use. The defects in 1919 were shrinkage, tendency to flow and similar conditions—all pointed out in the original works of Black and other pioneers in dental research. In 1929, through the coöperation with the American Dental Association, eighteen popular brands of amalgam alloys out of forty-four were found to be satisfactory. Today the American Dental Association has in its possession documents from the manufacturers of twenty-eight brands of amalgam alloys definitely guaranteeing that these brands will continuously comply with the approved standards for amalgam alloys. Dentists will find these alloys at their supply houses, each package bearing a guarantee label. These alloys are sufficiently diversified in cut, working properties, and other individual qualities all of which are up to the safe standard, to meet the most exacting requirements.

Defective technics slowly disappearing. Unfortunately we cannot yet announce such an approach to perfection on the second item: manipulation or technic. Excessive time spent in amalgamating alloy may produce shrinkage. Proper means should be taken to compensate for dimensional shrinkage of cast-gold restorations. Properties of orthodontic appliances may often be improved 40 percent by heat treating. Foil gold has excellent properties in certain types of restorations. Probably less than 25 percent of the dental profession is giving serious attention to these important discoveries.

Scientific findings applied. The reports by Volland, Paffenbarger

and Taylor displaying laboratory-data curves and computations, as applied to problems of inlay construction, supported by practical examples of defective and safe technics, are classics in this field. They show the effects of using shrinking investments, which add to the difficulties of misfit encountered in the universal shrinkage of cast-gold alloys. Dentists had encountered numerous misfits in cast restoration, and accepted these as chargeable to their faulty technic. The fault was theirs only in so far as they had accepted untested and non-guaranteed investments. Careful study of these reports enables one to compute, from the data on the individual materials, exactly what results will be obtained in the finished casting. Through intelligent handling of wax, investment, and gold, dentists and others may now produce acceptable restorations by scientific means. I can think of no better example of "that point at which the science and the art meet and merge."

Better dental service. I predict for the entire dental profession, in the near future, a more nearly universal effort to assimilate the scientific discoveries emanating from the Bureau of Standards and other dental research laboratories, and to make the practical applications in their work. This will, of course, mean less work for root-canal specialists, periodontists, exodontists, and partial- and full-denture men. However, with the reductions in these fields of work, there will be increased confidence in the dentist's ability truly to *restore*, and this will increase the number who will seek adequate dental service.

15. DISCUSSION OF DR. SOUDER'S PAPER

C. T. Messner, D.D.S., U. S. Public Health Service, Washington, D. C.

Undoubtedly the application of science to research in dental materials is a turning point in dental practice. Dr. Souder's excellent paper clearly shows that the dentist should take advantage of the available scientific facts regarding dental materials and their application. Unfortunately, such is not always the case, regardless of repeated publications on these subjects. It seems almost unbelievable that, in the light of present knowledge concerning the properties and the manipulation of amalgams, proper means to compensate for dimensional changes in cast-gold restorations, heat treatment of orthodontic appliances, and golds used in dental practice, some dentists continue to accept inferior materials or use unscientific methods with which

they can not possibly hope to attain good results. So far, efforts to prevent or arrest dental caries have not met with great success, although fundamental facts are constantly being added to knowledge regarding this disease. It is safe to say that even if we could prevent or arrest caries, which attacks people of all classes, we would continue to be confronted with the problem of restoring lost teeth or lost tooth-structure, for only a comparatively few persons would avail themselves of the knowledge at hand. Dentists will always have to meet the problems of sealing cavities in teeth, and of replacing lost tooth-structure as nearly as possible to its original function. Undoubtedly the future will bring more perfect restorative materials for this purpose, but the progress made in the last few years has been remarkable.

Since 1928 the organized dental profession, through the Research Commission of the American Dental Association, has been taking a leading part in scientific research into dental materials. The coöperative fellowship to which Dr. Souder referred was financed by a grant of $10,000 from the American Dental Association and an equal amount from the Government through appropriations made to the Bureau of Standards. This work has been carried on under the immediate supervision of Dr. Souder, who has given unsparingly of his time and wide experience. The Research Associates now supported by the American Dental Association are George Paffenbarger, D.D.S., and W. T. Sweeney, A.B. These gentlemen are enthusiastic about their work. Their laboratories are well-equipped, and open to visitors. Unfortunately, the Government appropriation for this work has been reduced by half during the past year, and, owing to economy measures, it was also necessary for the American Dental Association to reduce its appropriation a few hundred dollars. This, of course, has retarded the work to some extent, but it is hoped that the original appropriations will soon be restored.

It is encouraging to note that the *leading* manufacturers of dental materials in America are coöperating with the work at the Bureau of Standards. However, stubborn opposition is sometimes encountered; at other times, there is indifference or carelessness among manufacturers. As a result, a large number of dental amalgams on the market do not meet the specifications that have been adopted by the Government and the American Dental Association. Dr. Souder told you that ten years after Black's researches were available, only four safe amalgams were found among fifteen *leading* brands. Ten years later, or twenty years after Black pointed out the defects of shrinkage, flow, etc., only eighteen of fourty-four *leading* brands met the requirements of organized dentistry. Recently, as Secretary of the Research Commission of the American Dental Association, I was given documents by Dr. Souder and his associates showing that of thirty-three different

amalgams manufactured by twenty-one *prominent* manufacturers—all having been labeled as *guaranteed* to meet specifications of the Bureau of Standards—nine were found to be defective. This clearly shows that, although some manufacturers are willing and even glad to coöperate in testing and holding their products to a high standard, *others are evidently interested only in selling their products, even by questionable methods.* So long as dentists are indifferent to the quality of the materials they use, various manufacturers will continue to be unconcerned in the methods of preparing and testing their products. Amalgams that pass the specifications will again be published this year. *Dentists universally should insist that the materials they purchase are of a quality that, with due care, will make it possible to render efficient service.*

It is hoped that the work at the Bureau of Standards will continue, and will include practically all dental materials. Considerable work has recently been done on oxyphosphate cements. Specifications for these cements will be published at an early date. Silicate cements will be taken up later, as well as materials used in prosthetic appliances. Always there will be a constant checking and re-checking of materials purchased in the open market, as is now being done with amalgams. One of the greatest needs is the adoption by the American Dental Association of some plan by which manufacturers who state that their products meet the specifications of the Government and the American Dental Association can be *compelled* to furnish materials of the specified quality. Recently this matter has been brought before the Federal Trade Commission for further consideration.

16. MORPHOLOGICAL CHANGES IN THE MUCOUS MEMBRANE COVERING EDENTULOUS AREAS OF THE ALVEOLAR PROCESS IN THE HUMAN MOUTH

Walter H. Wright, D.D.S., University of Pittsburgh, Pittsburgh, Pa.

This paper pointed out and defined characteristic morphological changes in the mucous membrane that may result from conditions of abnormal masticatory pressure owing to breaks in the dental arch. Five groups of mucous membrane were studied. The *first* group included membrane, from a normal environment, showing a symmetrical form and normal pattern of the epithelial and connective tissue. Membrane in the *second* group had been subject to direct pressures from food, during mastication. The epithelium showed proliferation into the underlying stroma and also cornification of the surface cells. In the

third group, the membrane had been traumatized by contact with opposing teeth. The papillae were frequently blunt or club-shaped under conditions of moderate pressure; they were greatly reduced in size, or lacking, under severe pressure. Cornified cells had been worn away by abrasion, although they were present in unabraded areas of the same specimen. The membrane in the *fourth* group had been protected by tooth-supported bridge-work. The tissues were loosely arranged, irregular in form, devoid of cornification, and frequently edematous. In the *fifth* group, the membrane had supported prosthetic dentures and presented various forms. In some specimens the epithelium was normal; in others, abraded. Frequently the connective tissue was arranged in bundles parallel to the surface, and infiltrated with round cells and plasma cells. There was no cornification.

The author concluded that a break in the dental arch causes abnormal distribution of masticatory pressure upon the mucous membrane surrounding the remaining teeth, ensuing morphological changes in the membrane varying in degree with the angle at which the food strikes the tissue, the size of the break in the arch, and the occlusal relations of the teeth. Cornification of oral epithelium results from the brushing of the tissues by foods during mastication, its thickness being proportionate to the brushing action. It is worn off by very severe pressure, and is generally lacking under prosthetic dentures and bridgework. Dental restorations of all types must be correctly made to maintain the health of the surrounding mucous membrane. Neglect of the tissues surrounding the natural teeth may seriously impair the service that later may be desired from prosthetic dentures.

17. DISCUSSION OF DR. WRIGHT'S PAPER

Clyde H. Schuyler, D.D.S., New York University, New York City

I have carefully studied Dr. Wright's paper and pictures and have found them interesting and illuminating. For many years I have respected our essayist as a scientist, and as one whose untiring efforts have been of inestimable value to the progress of dentistry. His careful and precise presentation illustrates what we have come to expect of his work. I would not endeavor to discuss his presentation had it not been possible for me to obtain the coöperation of my colleague, C. G. Darlington, M.D., Assistant Professor of Pathology.

It would be interesting to learn how many specimens of each class were studied; how the sections were secured; what portion was from cadavers, what portion from patients. Dr. Wright speaks of one section as showing the normal mucous membrane, and of others as being characteristic of a class. There are so many variations in the normal that it is rather difficult to classify one section as such, except as it may be compared with the pathological, or to picture one section as characteristic of a class. There are a few matters I think Dr. Wright could clarify by a more detailed explanation of his studies. For instance, he has shown wide variations in the pattern of the mucous membrane as due to conditions such as location, nature of stimulation, etc. I wonder in what way these variations might be affected by age, sex, general physical condition, tobacco, and duration of stimulus. There might be some reason to question the interpretation of some sections. For example, in referring to the second plate he explains: "The presence of small round-cells indicates a slight inflammation." It would seem that this condition is more than slight. In discussing the fourth plate, Dr. Wright speaks of the tissue as being "in the critical condition that occurs just prior to ulceration." Here the seriousness of this condition appears to be questionable. It is probably simple pressure-atrophic change. However, it is more difficult to obtain an accurate conception of true conditions from photographs, than directly from specimens.

I am in hearty accord with Dr. Wright's general deductions and conclusions. It is true that the most difficult cases for which the prosthodontist is requested to construct prosthetic restorations are those where teeth have been lost owing to peridental infection. Too many people consider their dental troubles to be at an end when artificial restorations have been made, whereas at best these restorations must be compared in efficiency with an artificial limb, or similar substitutes; from which only a limited degree of efficiency as compared with the natural can be expected, and which require tolerance and coöperation from the patient. It must be impressed upon the patient, furthermore, that the base upon which the prosthodontist builds is constantly undergoing change, and that periodic adjustments and replacements, to ensure retention of balanced occlusion and physiological adaptation of bases to the tissue, are necessary for the continued health of the supporting tissues and the maintenance of a high degree of efficiency.

The medical and dental professions must jointly assume the responsibility to build and preserve the oral structures through diet and prophylactic measures, so that the health of the natural dentition may be preserved throughout life. The intelligent coöperation of the two professions must begin with

the expectant mother, and extend through the life of the patient, with early recognition and correction of dental defects.

V. Dental Participation in a General Session of the American Association for the Advancement of Science: Afternoon (4:45); Abstracts 18–19

18. Introduction[7]

Howard T. Karsner, M.D., Western Reserve University, Cleveland, Ohio; Retiring Vice-President for Section N, American Association for the Advancement of Science

In opening this general session of the American Association for the Advancement of Science, it is a pleasure officially and personally to welcome into the group of affiliated societies the American College of Dentists. This organization represents the highest ideals of the dental profession and, as will be seen from an examination of today's program, presents for discussion some of the most significant advances in dental science. The field of dental research covers a wide variety of topics in pure and applied science. For this reason the new affiliation is of special interest. The science of dentistry has progressed far in a comparatively short time, and comes into our group in full maturity, with great promise of further fruitful development.

It is particularly fortunate that the topic of the lecture to be presented this afternoon is dental caries, a disease widespread and with many implications. The speaker has critically studied this condition from clinical, biochemical, bacteriological, dietary and other points of view, illustrating well the many facets of dental research. For more than twenty years these investigations have gone forward not only in the laboratory but in the clinic, and in three large orphanages where careful control of groups of individuals has been possible. I consider it a pleasure and an honor to present Russell W. Bunting, D.D.S., D.D.Sc., F.A.C.D., Professor of Oral Histology and Pathology, University of Michigan; Fellow of the American College of Dentists; Past President of the Michigan State Dental Society, and of the American Institute of Dental Teachers; recipient of the Callahan Me-

[7] Dr. Karsner opened the session and introduced Dr. Bunting. Dr. Alfred Walker, D.D.S., Guggenheim Dental Clinic, New York City, presided to the end of the session.

morial Award; contributor to the American Text Book of Operative Dentistry; author of a widely used text book on Oral Pathology; and Director of Dental Caries Research under the auspices of the Children's Fund of Michigan.

19. RECENT DEVELOPMENTS IN THE STUDY OF DENTAL CARIES[8]

Russell W. Bunting, D.D.S., D.D.Sc., University of Michigan, Ann Arbor, Mich.

Decay of teeth is the most common disease of mankind. Considerable scientific research is being carried on to determine means of either reducing or preventing the occurrence of this disease. As a result of these investigations certain facts have been established, and many preconceived ideas have been shown to be erroneous. The problem has not been solved, nor have practical means of preventing the disease been discovered, but distinct advances have been made toward ultimate solution of the problem. Certain of the more outstanding principles that have been established are summarized below.

(1) The active cause of dental caries is a specific type of bacterium, which inhabits the mouths of certain individuals, but is absent or present only in small numbers in persons who have little or no dental disease. This organism attacks the teeth through the action of acids formed in fermentation of carbohydrate food retained in the mouth. It belongs to the lacto-bacillus group of bacteria, and is generally known as B. acidophilus.

(2) The occurrence of dental caries is not determined by the hardness or softness of teeth, nor by the cleanliness of the mouth. Hard

[8] Quotation from "General sessions of the Association:" *Science*, 1933, 77, 134; Feb. 3.—"On Friday afternoon there were two general lectures, one by Prof. Russell W. Bunting, of the University of Michigan, ... Dr. Bunting's subject was "Recent Developments in the Study of Dental Caries." He pointed out that this is the most common human disease of civilization, but that it is not generally common or very serious among uncivilized peoples. It is caused by a bacterium of the lacto-bacillus group, which is present only in small numbers, or is absent, in the mouths of persons with little or no dental decay. Some persons are immune and immunological study may sometime make prevention possible. Diet may be important, but conclusions are not yet possible in that respect. Oral cleanliness retards the progress of the lesions, but does not appear to prevent their inception. This disease requires much more study, with the correlation of findings in various fields of science."

and well formed teeth and mouth cleanliness, highly desirable qualities that affect the rate of progress, do not, in themselves, control the occurrence of this disease.

(3) The occurrence of dental caries is very definitely influenced by certain constitutional states of the individual, such as inherited characteristics, age, bodily health, and nutrition. The tendency to dental disease definitely runs in families; it is greater during childhood and less in adult life; it often increases during illness or pregnancy; and seems to be related to the type of individual diet.

(4) Dental caries is distinctly a disease of civilization. Uncivilized people, as a rule, have little or no dental decay, but when they adopt civilized diets and modes of living they are often seriously affected.

(5) An immune principle against B. acidophilus has been found in the blood serum of individuals who are free from dental caries. This phase is being studied with a view to possible immunization against the disease.

(6) Dental caries has been greatly reduced or prevented in several groups of children who have been given different types of adequate diet. As yet no single dietary constituent has been found to be more important than another. The only factor common to all the beneficial diets was that they were fairly adequate to the needs of the individual. One exception was noted in a group of orphanage children: they received a poor diet that was extremely low in sugar, and their teeth were practically free from active caries over a four-year period of observation. There is an accumulation of evidence showing that sugar intake may be a very important factor in the activity of dental caries. At present no definite conclusions may be drawn from any of the dietary experimentation.

It is very desirable that this problem be subjected to intensive group-studies in which the various sciences involved may be correlated to complete the work already done, with the hope that in the very near future practical means to control this disease may be devised.

VI. Third Session: Evening (Dinner); Abstracts 20–25

20. THREE EPOCHS OF DENTAL RESEARCH[9]

U. Garfield Rickert, A.M., D.D.S., D.D.Sc., University of Michigan, Ann Arbor, Mich.; Chairman of the third session

Excepting such notable discoveries as the application of general anesthesia in surgery and the use of air pressure for the retention of artificial dentures, in the first epoch—and, in the second epoch, the work on the cause and control of dental caries, the extensive investigations of dental foci of infection, and the metallurgical research—the first century of American dentistry was not replete with research activity. The two outstanding problems to be solved in the epoch we are now entering, other than the caries problem, are development of more suitable materials for dental restorations, and application of economic principles to facilitate further extension of dental services.

Recent advances in chemistry enable us to determine more accurately the essential requirements of materials to be used in restorations, and the chemist will probably, by synthesis, more adequately meet our needs. During the first two epochs the only materials available to the dentist were such as approximated his needs without fully meeting them. Under these conditions gold, silver, and platinum came into use. These metals have three distinct disadvantages. (*a*) They favor low-grade irritations of the sensitive pulps owing to their thermal and electric conductivities, and thus promote degenerative changes that frequently initiate acute secondary effects involving the eyes, muscles, and other parts of the body. (*b*) They are objectionable from an esthetic standpoint. Many persons, especially American women, refuse to have metals placed in conspicuous parts of the mouth. (*c*) The cost of precious metals has added so much to the cost of dental services that even during the most prosperous times only about 10 percent of our people could afford gold restorations. It is estimated that over $12,000,000 of this metal was used for dental purposes in the depression year of 1931. We should not overlook the fact that, unless future generations mine the tombs of the present age, the gold used in

[9] In this paper the author assumed that American dentistry can be conveniently divided into three epochs of fifty years each, the first one beginning about 1830, thus: 1830–1879; 1880–1929; 1930–1979.

dentistry is a permanent economic loss. Many writers have been fascinated by the thought of the amount of gold lost at sea. More interesting to the dental research worker is the knowledge that, if every one in our population could and would avail himself of the "gold-standard dentistry" of the past epoch, the *annual* loss would be greater than the recorded loss at sea for all time.

Since it is the aim of dentistry to extend its services until all our people can avail themselves of its blessings, it becomes imperative that dentistry should abandon the "gold standard." The masses could never afford dental restorations made of precious metals, and, for economic reasons, no nation would permit so extensive a withdrawal, even if the people as individuals could afford it. Gold has been and still is, when used by a skillful operator, the most reliable restorative material. However, the encouraging results we have had in our own laboratory with synthetic products indicates that long before the beginning of the next epoch in dental research, precious metals will have been abandoned for restorations in all save, perhaps, exceptional cases.

21. DISCUSSION OF DR. RICKERT'S PAPER

Alfred Walker, D.D.S., Guggenheim Dental Clinic, New York City

The developments in various branches of dental practice, and the researches that have made these developments possible, have been admirably covered by Dr. Rickert. He is correct when he says that the problem of control of dental caries is first in importance as we pass from the second to the third epoch. If and when we learn how to prevent or satisfactorily limit dental caries, we shall have put an end to the conditions leading to pulp death or extirpation, and shall have eliminated much of the malposition of teeth that is recognized as one of the most common causes of pyorrhea. Dr. Rickert mentioned the fundamental researches of Miller and Black on the causes of dental caries. It seems well to emphasize to even a greater degree the achievements of these men at a time when scientific dental research was in its infancy. To have built up a theory that has withstood both friendly and antagonistic criticism was no small accomplishment. What is needed now is an orderly progression of integrated researches to confirm or disprove, once and for all, Miller's theory, and then to carry on to the establishment of a practicable program for the control of a disease that is even more prevalent than the common cold.

In order that future research may be carried forward efficiently, I believe the first requisite is the appointment of a director of research. As I look about at researches in complex problems outside of the dental field, I am impressed by the need of securing, for such a position, not necessarily a dentist, but someone whose research activities have covered a broader field. This director would first bring together in concise form the results of the investigations so far reported. He would also reduce to concise form the observations on caries as regards immunity and susceptibility thereto, in various racial groups and geographical areas. These observations would include the items of food habits, climatic conditions, water supply, personal hygiene and community sanitation, housing conditions, susceptibility to other diseases, and such factors as might be considered to have a possible bearing thereon. Under clinical observations there would also be brought together information regarding incidence of caries in families, both as regards similar and dissimilar susceptibilities, and localization of carious surfaces in individual mouths. The director would develop a plan for research in which all apparently pertinent elements might find their proper place, and under this plan would assign certain problems to each research worker or group, with the injunction that each particular problem should be studied in the light of its relationship to the plan as a whole. The feasibility of such a plan must be apparent when we take into consideration that in the past no comprehensive attempt has been made to correlate the results of laboratory research with clinical observations.

Dietary factors are believed to play an important part, and those who advocate certain kinds of foods both from the standpoint of their chemical content and their vitaminic influences are not in agreement. On the other hand, we learn of racial groups who do not partake of any of the advocated foods, and yet who enjoy immunity to dental caries. The complexity of the problem, and the importance of correlating laboratory results with clinical facts, make it essential that research under this plan be organized and carried forward under professional control.

22. THE PROGRESS OF MICROSCOPIC RESEARCH IN PERIODONTAL DISEASES

Rudolf Kronfeld, M.D., Loyola University, Chicago, Ill.

The tooth is surrounded and supported by gingival tissues, periodontal membrane, and alveolar bone. To these structures the general term periodontium is applied. Consequently, all abnormal conditions in these tissues are covered by the name periodontal diseases. The

word pyorrhea, describing only one of the clinical symptoms of periodontal disease, is commonly used by the dental and medical professions, and the public, to apply to all manifestations of this disease. For a long time it has been known to clinicians that there are at least two distinctly different types of periodontal disease. Recent extensive microscopic examination of human-jaw specimens has fully confirmed and further elaborated this clinical observation.

The most common type of periodontal disease, found to some extent at least in about 90 percent of all mouths, consists of chronic inflammation of gingival tissue caused by local irritation. The gingivae are swollen and red and bleed easily with minor mechanical irritation, such as brushing; sometimes there is slight discharge of pus. Calculus, poor dental restorations, and negligence in oral care and cleanliness are the most common causes. The teeth remain firm for a long time, since the deeper periodontal structures—periodontal membrane and alveolar bone—are for the most part intact. Good dentistry, removal of calculus, and proper use of a good, hard tooth-brush promptly clear up this type of periodontal disease.

Another and much more serious type of periodontal disease consists of a deep lesion of the jaw bone and periodontal membrane, while the superficial soft tissues remain, at least in the first stages, practically normal. The early symptoms of such a deep bone-lesion are loosening and drifting of teeth and formation of diastemas. Later, deep paradental pockets develop around the affected teeth. Many of the teeth thus involved become so loose, within a comparatively short period of time, that they have to be extracted. Fortunately this type of periodontal disease is rather rare. Its cause is not yet generally understood, but there can be no doubt that a systemic disturbance is responsible. Diabetes, pregnancy, glandular disturbances, and dietary deficiencies are some of the causes. Decision in each case can usually be reached only by close coöperation between dentist and physician.

23. DISCUSSION OF DR. KRONFELD'S PAPER

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Dr. Kronfeld has presented an admirable paper. I shall call attention to a few matters on which difference of opinion may be pertinent. Dr. Kronfeld's description of the epithelial attachment and the logical

reasons for its presence need no comment. The epithelial attachment is continuous with the "dental cuticle," which entirely envelopes the tooth. This is not only a remnant of the enamel organ, whose function is lost at birth, but is a necessary influence in the preservation of the tooth. Proper tooth-brushing with a stiff-bristle tooth-brush helps to produce a hornified epithelial layer derived from the oral epithelium, which, together with the cuticle, protects the so-called gingival crevice. The dental cuticle has been demonstrated in grooves and at the necks of teeth in adult life of man and lower animals. Although, as Dr. Kronfeld points out, the ideal crevice has no depth, the 2-mm. crevices are so constant after about 25 years of age as to seem normal. In treatment it is practically impossible, either conservatively or surgically, to reduce the crevice to less than 2 mm. This is, therefore, presumably normal, and should not be confused with the space left in a specimen after the enamel has been decalcified.

Periodontitis simplex, or marginal gingivitis, is caused by external irritation, but may also be found with non-occlusion and anemias. Dr. Kronfeld says that "the second type (Gottlieb's diffuse atrophy, Box's complex periodontitis) can be considered an oral manifestation of some kind of systemic disease." We know that otherwise healthy patients may have the complex type; also that the disease does not clear up in unhealthy individuals as health improves. The neglected factor here is traumagenic occlusion. Where, as Dr. Kronfeld says, only one or two pockets are present, they may be due to food impaction or other local cause. This is an argument against a systemic background for all cases. Treatment of occlusion should not take the tooth out of function, but rather give it the function it can stand. Pregnancy, diabetes, vitamin deficiencies, syphilis, tuberculosis, etc., may either be primary factors in some cases, or produce a characteristic modification of the local disease.

The early clinical symptoms of loosening and drifting of teeth must be preceded either by previous loss of a member of the dental arch (especially a first molar, upper or lower), or a primary malposition of teeth, producing a loss of supporting contact. Dr. Kronfeld said: "In case of lateral drifting of a tooth, a deep pocket is usually found on the side away from which the tooth has drifted." Also: "In other cases the etiology is undue occlusal stress in a lateral (horizontal) direction; as a result, sometimes there is a deep pocket on the side toward which the tooth is being pressed." The two statements annul each other. A tooth cannot drift toward stress, it must move away from it. Therefore, if the stress that has instigated migratory pyorrhea produces a pocket, it must be on the side toward which the tooth is drifting. However, because the stress is not consistently in one

direction a pocket may be present on both sides. Drifting in a vertical direction is possible only when the opposing tooth is absent, or out of position so that it does not interfere. Dr. Kronfeld expressed the opinion that "it remains to be proved whether there can be a functional reattachment to a portion of a root surface that has once been denuded." Reattachment can be produced clinically. In one specimen of Dr. McCall's it has been shown microscopically. The difficulty of obtaining material of this sort is apparent since no patient wants to have extracted a tooth that has been successfully treated. We hope to obtain evidence of this type in the future. Radiographically, we have shown bone regeneration in many cases.

When teeth are lost the other members of the arch do not always take up the entire burden. An adaptation takes place in peridental membrane, bone, and musculature. There is actually reduction in the pressure the jaws are able to produce. The difficulty of eliciting the effects of a traumagenic occlusion in animals is, as Dr. Kronfeld intimates, due to the greater resistance. The fact that all humans have not this resistance makes study of this factor all the more important.

24. NEW LIGHT ON THE CAUSE AND CONTROL OF TOOTH DECAY IN MAN FROM FIELD STUDIES OF PRIMITIVE DISTRICTS PROVIDING IMMUNITY

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Primitive races of the past, and their remnants of the present, have been and are largely immune to dental caries, while modern civilizations have so generally lost their immunity that tooth decay is now not only the most prevalent of modern diseases, but also one of the most serious affections of mankind. In these studies it has been found that individuals having ***immunity*** were receiving foods liberal in fat-soluble activators and high in minerals as provided in natural foods in association with energy-carrying factors that were not in concentrated form or high in calories; whereas, those individuals having high ***susceptibility*** to dental caries were receiving foods very high in energy-carrying factors and relatively low in content of minerals and fat-soluble activators. A circumstance of much importance has developed in all the groups with high immunity; namely, they had practically no knowledge of oral-hygiene methods nor showed evidence of oral prophylaxis. Their immunity to tooth decay existed in spite of the fact that they did not have the aid of an efficient oral-hygiene procedure.

These studies have also shown that the characteristics of the foods found adequate to produce immunity to dental caries have not been limited to any one formula nor dependent upon hardness or softness of foods. For example, cereals were an important part of the diet in the Alps and Outer Hebrides and Porto Santa; rye, in the former, and oats in the latter two; but no cereals are available in Tristan da Cunha. Dairy products were available in the Alps but almost absent in the Outer Hebrides. Fish products were available and used liberally in the Outer Hebrides and Tristan da Cunha, but not available in the Alps. These are only a few illustrations of the wide divergence of foods that are adequate to produce immunity to dental caries. If the factors that control immunity to dental caries are an adequate level of fat-soluble activators and minerals in available form, then the reinforcement of modern dietaries with these factors should accomplish a control or prevention of susceptibility to dental caries. This has already been accomplished in several groups, as previously reported.

In a particularly instructive investigation, in progress during the past two years, children with rampant tooth-decay have been fed one reinforced meal a day for six days a week, in order to determine the possibility that this reinforcement could change susceptibility to immunity. These studies are also accompanied by a detailed chemical analysis of the saliva of the individuals before, during, and after treatment, and also roentgenograms. In forty children receiving the author's special meal, from February to June, 1932, fed by the staff of the Broadway Methodist Episcopal Mission (Cleveland) under the guidance of Rev. E. A. Brown, there was apparently complete control of tooth decay, with no evidence of new cavities, as determined by clinical examinations and roentgenograms made before, during, and after treatment. There was also evidence of marked mineralization of decalcified dentin where teeth were not filled, and of a building-in of new pulpal walls where dentin had been decalcified to the pulp chamber. Associated with the change from susceptibility to immunity there has been a change in the chemical characteristics of the saliva in the behavior of inorganic P in the presence of powdered bone. The results indicate the establishment of a high factor of safety through the means of six specially reinforced meals a week.

These studies support the conclusion that the saliva determines the

environment of the tooth, and thereby provides the factors which control immunity and susceptibility to tooth decay. The level of these factors in the saliva is determined by the blood stream, which is controlled primarily by nutrition. The rôle of the aciduric bacteria is now clearer. (The text, of which this is an abstract, is liberally provided with illustrations, graphs, and tables. The personal field studies herein reported were made in 1931 and 1932 in the Alps, and in 1932 in the Outer Hebrides.)

25. DISCUSSION OF DR. PRICE'S PAPER

Henry Klein, D.D.S., Sc.D., Johns Hopkins University, Baltimore, Md.

The discussion considered the wide scope of Dr. Price's paper, and was chiefly concerned with pointing out the lack of detail, in the paper, concerning the methods used in the chemical analysis of the salivas and foods.

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